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ARTHUR SEARLE.

By MARGARET HARWOOD.

A man who has studied deeply into one subject usually has a general knowledge in many fields, but we rarely find an individual so accurately informed in regard to almost every branch of learning that he may be called an authority in any one. Such a man, however, was one of the most retiring and modest of men, Professor Arthur Searle, who died at his home in Cambridge, Mass., October 23, 1920.

He was born in London, England, October 21, 1837, the eldest son of Thomas and Anne (Noble) Searle. His mother came from Derby, England, and was of English birth and ancestry. His father, although a partner in a firm of London bankers, was a citizen of the United States and came of an old New England family. He was a descendant of Thomas Dudley, the second Governor of Massachusetts. In 1840, Thomas Searle returned to the United States with his wife and two sons. The parents died within the next two years, leaving the children to the care of an uncle and aunt who lived in Brookline, Mass.

Arthur Searle received his early education in private schools of Brookline and Roxbury and in the Brookline High School from which he entered Harvard College in 1852 at the age of fourteen. In college he stood high in his studies, graduating in 1856 as the second scholar in the class. Ancient and modern languages, philosophy, mathematics, and the sciences all interested him deeply, and in each of them he seems to have been an equally good student. He had also a keen appreciation of music.

After graduating from college he taught for two years in the Boston Latin School and in a private school. Then owing to ill health he took up farming, alternating it with tutoring, until in 1861 he joined a party of young men who planned to become sheep farmers in California, whither they went by way of the Isthmus of Panama. After a preliminary trial the scheme was abandoned and the party broke up. While waiting for the return of some of the money he had put into the adventure, Mr. Searle taught English and Logic for a term at the University of the Pacific, Santa Clara. However, he still intended to persevere in an agricultural career and did considerable travelling in Cali-

fornia to inspect the best farming districts. But before he came to any decision he was summoned home to Brookline to help care for his aunt during her last illness.

During the next four years he was a clerk in the office of Head and Perkins, brokers, in Boston. He spent the years 1866 and 1867 in tutoring and in computing for the United States Sanitary Commission.

Meanwhile his brother, later known as the Reverend George Mary Searle, Superior General of the Congregation of St. Paul, was especially interested in mathematics and astronomy and held positions first at the Dudley Observatory, at the U. S. Naval Academy, and finally at the Harvard College Observatory. He became a Roman Catholic and in 1868 decided to study for the priesthood, joining the Congregation of St. Paul in New York City. In taking this step Father Searle did not abandon astronomy entirely; he continued to make and to publish various investigations in theoretical astronomy, and also made several inventions of astronomical apparatus, as well as a range-finder for cannon. His departure from the Harvard Observatory, however, left a vacancy which his brother Arthur was invited to fill. The latter had never shown special interest in astronomy but everything of a scientific nature appealed to him. By the time he was nine years old he had amused himself by performing chemical experiments afterwards prescribed in his college course. He had occasionally written articles on astronomical subjects. One of these, "The Plurality of Worlds," was published in the Harvard Magazine in 1854.

Accordingly on April 1, 1868, Mr. Searle began work at the Harvard College Observatory as computer and observer, under the impression, as he stated himself in after years, that this situation would be no more permanent than those which he had previously occupied. To his surprise he found the work better suited to him than he had supposed. He had all the qualities of a scientific investigator, for to his clear, active mind, method, accuracy, and precision were second nature. He did not consider himself a born astronomer, however, and often gave the reason that if he had been he would have accepted an invitation from Dr. Benjamin A. Gould to accompany him in 1869 to South America to be an assistant in the newly established Argentine Observatory at Cordoba. But he was tired of shifting from one thing to another and preferred to stay in one place for a time at least.

In the autumn of 1869 he was appointed Assistant at the Observatory of Harvard College. He was often employed in the business management of the Observatory. This was especially the case after the death of the Director, Professor Joseph Winlock, in 1875. Mr. Searle was then placed in charge of the Observatory until Professor Edward C. Pickering became Director in 1877. Mr. Searle became Assistant Professor in 1883, Phillips Professor of Astronomy in 1887, and Phillips Professor, *Emeritus*, in 1912.

His early astronomical work included both micrometric and photometric observations of stars, double stars, and variable stars, satellites

of the planets, asteroids and comets, and the routine computing necessary with the compilation of such observations. These are published in four volumes of the Annals of the Harvard College Observatory. He also collected and published in the Annals the meteorological observations made at the Observatory between 1840 and 1888, and wrote an historical account of the Observatory from 1855 to 1876.

In 1874 he undertook his first independent inquiry which related to the Zodiacal Light. Together with the routine observational work mentioned above he observed both the Zodiacal Light and Gegenschein at whatever occasional moments were available from 1874 until 1895. The results of these observations are contained in the Astronomische Nachrichten, Vols. 99, 102, 109, 116, 124, 126; in the Proceedings of the American Academy of Sciences, Vol. 19; in the Memoirs of the American Academy, Vol. 11; and in the Annals of the Harvard College Observatory, Vols. 19, Part 2, and 33, Nos. 1, 2 and 3. He also wrote occasional summaries of information on the subject for the Monthly Weather Review and the Laboratory Manual of Astronomy by Miss Mary E. Byrd.

The main topics to which he directed his attention are as follows: first, the permanence, position, and magnitude of the ordinary western zodiacal light; second, the normal distribution of light in the zodiac and its vicinity, which evidently affects all observations of the fainter portions of the zodiacal light, at great elongations; third, the phenomenon of a feeble maximum of light in opposition to the Sun, known as Gegenschein, its position, parallax, and brightness. Although his results allowed him to conclude that the most likely hypothesis with regard to the origin of the zodiacal light is that which ascribes it to reflection from small meteoric bodies, nevertheless he maintained that his hypothesis needs to be confirmed or invalidated by more definite observations of the zodiacal light itself, as well as by further researches respecting the orbital movements and the light of asteroids and periodic comets. He saw that before any further theorizing can be done, it is necessary to have long series of observations of the posiion and brightness of the zodiacal light and Gegenschein, taken during a considerable number of years. These should be made simultaneously by at least two observers, who work independently, but on exactly the same system, first at the same place and later at different places.

After 1895 the increasing use of electric light in the neighborhood of the Observatory made further observations of the zodiacal light in Cambridge impossible. Other work and increasing age prevented him from again carrying on observations in any rural locality not bothered by artificial light, but he always continued to feel a keen interest in the subject and hoped to find younger observers who would carry out his plan.

From 1888 to 1898 Professor Searle made meridian circle observations for the Zone Catalogue of 8337 Stars between 9° 50′ and 14° 10′ of South Declination in 1855 for the Epoch 1900.0. The results of this

work fill five volumes of the Annals of Harvard College Observatory, Vols. 62, 65, 66, 67, 77. The Catalogue itself, which is Volume 67, was published in coöperation with the Astronomische Gesellschaft. Although the reduction and publication of these observations took an untold amount of energy and patience until 1912, Professor Searle regarded it merely as the result of his routine observatory work and accordingly not a personal undertaking. But various investigations relating to meridian circle observations which were suggested by the progress of the work required for the Catalogue, should most certainly be regarded as the result of his own skill and ingenuity. The references to these will be found in the Introduction to Harvard Annals, Vol. 67. Two articles in particular should be mentioned here. They are: "Geometrical Methods in the Theory of Combining Observations," and "Results of Accessory Series of Observations made with the Meridian Circle of Harvard College Observatory." The latter contains a study of the effect of magnitude on personal equation, of fatigue, and other sources of error.

A paper on "The Atmospheric Economy of Solar Radiation" which was presented before the American Academy of Sciences in 1888, was doubtless a result of his work on the meteorological records previously mentioned.

He occasionally wrote for magazines, notably the Atlantic Monthly. "Mars as a Neighbor," which appeared in 1878, and "The Discovery of a New Stellar System," relating to variable stars, published in 1892, are two articles of general information. In such papers as these, as well as in his textbook "Outlines of Astronomy," of which two editions were published in 1874 and 1875, Professor Searle displayed his ingenuity in his methods of suggesting to the reader that he must think for himself. This quality made itself felt in his teaching, and consequently his students came to regard his course in astronomy at Radcliffe College as a liberal education. He conducted this course between the years 1891 and 1912 when he retired. Any lack of clear thinking on the part of a student would strike him as the best possible joke, and would cause him to break out into a hearty laugh, in which even the victim would join. No feelings could be hurt by this laughter, which was always followed by a careful explanation of the subject in question, given with the utmost patience.

Mr. Searle was married January 1, 1873, to Emma Wesselhoeft, daughter of Dr. Robert Wesselhoeft of Boston and Brattleboro, Vt. There was a peculiar charm in the simplicity and whole hearted hospitality of their home. Mrs. Searle was quietly active in philanthropic work. In all cases of want or distress that came to her attention, Mr. Searle also took the interest of a friend and was always a generous coöperator. Those whom they assisted, as well as all who worked for them, came to regard both as close and dear friends. Mrs. Searle died December 19, 1914. They are survived by two daughters.

In speaking of Professor Searle's publications, the writer cannot pre-

tend to give an adequate review of his philosophical essays, "Essays I-XXX" which were published in 1910. It is interesting to note, however, that in the six essays entitled "Space and Time," he gives an explanation, wholly independent of other authorities, of the modern principle of relativity.

After his retirement in 1912, Professor Searle's work lay chiefly in the field of mathematical astronomy. At the time of his death he had practically completed a treatise on "Geometrical Results from Actual and Assumed Laws of Motion." These results are derived from elementary algebra and plane geometry without the use of trigonometry, or differential or integral calculus. A paper on "Orbits Resulting from Assumed Laws of Motion," but implying a knowledge of higher mathematics, was published in May, 1920, in the Proceedings of the American Academy of Arts and Sciences, Vol. 55. This paper, with the necessity of reference to higher mathematics eliminated, will be incorporated in the first treatise.

Professor Searle was interested in every branch of learning to the extent that he frequently inquired into subjects in no way allied to his own, and worked out points which naturally would concern only a specialist. For example, as a result of re-reading Caesar's "De Bello Civili" for recreation, he wrote in 1907 "A Note on the Battle of Pharsalus," which is published in Harvard Studies in Classical Philology, Vol. XVIII. This is an inquiry into the conditions which made possible Caesar's use of a body of infantry for frustrating the enemy's attempt to out-flank him with a superior force of cavalry.

Throughout his life he amused himself with the composition of occasional verse both in Latin and in English. It seems fitting to quote in closing his own paraphrase in English of a Latin poem "De Morte Sera," which he composed during the last illness of his wife. The Latin version has been published in the Harvard Graduates Magazine for March, 1921.

DEATH IN OLD AGE.

Night is at hand; thick darkness hides the road;
The traveler pauses, doubtful of his way,
And seeks for rest in some kind host's abode
Till the return of day.

Far from our native dwellings have we strayed,
And now, in need of rest for heart and head,
Enter through spacious portals, dim with shade,
The kingdom of the dead.

Dawn will recall the pilgrim to his task;
Whether for us such summons comes, who knows?
All that the guests of Nature have to ask
Is undisturbed repose.

Maria Mitchell Observatory,
Nantucket, Mass., May, 1921.

LOW SUN PHENOMENA—IV. The "Green Flash."

By WILLARD J. FISHER.

(Continued from page 265.)

The appearance of the "green flash" is capricious, as is agreed by all reasonably constant observers. There is no series of observations available for land horizons, but in Table 4 I have collected the data of four observers who have made reasonably long series with sea horizons, and in very varied localities. From these it seems that in about half the cases of marine sunrise or sunset observed, no "green flash" has been visible, though no apparent reason existed for its non-appearance. In Egypt, where, according to W. Groff (50), it is very common, he also says that "even sometimes when, in appearance, there are neither clouds nor haze, the phenomenon does not take place."

TABLE 4.

Observer	Place	Possibilities	Green Flash	Notes
A. Carpenter	Taormina	46	21	Binoculars x 4; horizon hazy, mist or dust, sun rose dull red, gold or white, 25.
W. Goodacre	Suez-S. India	12	8	Unaided eye?
H. Metcalfe	Fleetwood	13	6	Naked eye 3, opera glass 6.
A. A. Nijland	Circumnavigation	16	7	Naked eye?
	Totals	87	42	Green flash 48 per cent.

ADDITIONAL NOTES.

A. Carpenter records that 46 mornings the sunrise was hidden by clouds.

W. Goodacre says that of the 4 occasions when there was no flash seen, the conditions were apparently good on 3.

H. Metcalfe notes 10 times that the sea horizon was "clear," "very clear," "fine;" on three of these the green flash was not seen.

A. A. Nijland notes free horizon 9, ? 1, total 10; in 5 of these cases the green flash was not seen. Cases observed between the tropics, 12, green flash observed 5; outside the tropics, 4, green flash 2.

In various notices it is stated that a green flash, or blue, is sometimes to be observed at a cloud surface, or even at a level in the transparent air, as mentioned by Dr. Joule in Winstanley's original account. Not the least remarkable of these are cases when the green appears at a cloud surface, but not at a clear sea horizon directly afterward. I find two particularly instructive accounts of this sort.

H. Metcalfe (94, 95), says:

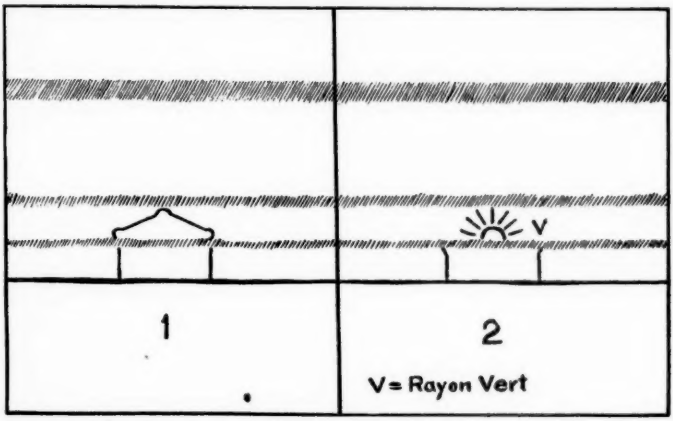
"No. 22. The disc of the sun, at first a bright orange color, finally became a light red at actual horizon, which was the sea. The disc was crossed by two narrow bands of cloud, the bottom edge of the lower cloud being separated by a clear space from the sea level. As the top of the sun disappeared behind the upper edge of the first cloud, there was visible a brief but fairly bright green flash.

"When the tip of the sun appeared below the lower edge of the

upper cloud, and disappeared at the upper edge of the second cloud, I saw a second green flash, but very faint. When, finally, the tip of the sun emerged from the lower edge of the second cloud, and disappeared below the sea horizon, I failed to see a third green flash, even though the conditions were apparently most favourable for its production."

The astronomer Rudaux says (128):

"On July 16 last (1904), after a fine hot day, the sun approached a superb sunset behind transparent trains of haze, distant stripes parallel to the horizon. Under these conditions the sun's disc showed successive deformations, extremely curious, due, as is well known, to unequal refractions. The most characteristic of these is shown in the sketch, Fig. 1. But as the little cap at the top, separated from the rest by a band of haze, was about to disappear, the green ray manifested itself in all its splendor above the upper edge of this haze, Fig. 2. Then



the sun's disk, continuously descending, disappeared a little later at the real horizon without the phenomenon taking place there—I expected to see it again. This is the first time at the Observatory of Donville that I have had the chance to make such an observation of the green ray, though in general I see it very frequently under ordinary circumstances of visibility."

For observations such as these the simple dispersion theory cannot account; the green flash is not due solely to the cutting off by the horizon, or a cloud layer, of the red to yellow images of the sun, but also to special conditions existing in the atmospheric layers at the horizon or the cloud layer. Such conditions are tested for us by the form of the sun's limb near the horizon, which Arendt calls "a very sensitive reagent" for the purpose. Consequently I have examined the published data for statements of the deformations as well as of the color effects observed. Unfortunately there is very little to be found, less than for the capriciousness of the green flash.

In Jules Verne's story, in the culminating chapter, where the group of seekers all (except the lovers) finally see "Le Rayon Vert", the form of the descending sun is described as like that of an Etruscan vase, whose foot was plunged in the water.

C. T. Whitmell (152) says:

"With clear sunsets the successes have outnumbered the failures. I think also that the flash has usually been the more marked when the atmospheric refraction was of such a kind as to cause evident quivering and distortion of the sun's disc. To the best of my recollection, failures were associated with a steady oval disc."

In the notes to A. A. Nijland's table of observations (107), in five cases it is stated that the sun on the horizon was greatly distorted; of these, four failed to show any green flash; but there is no indication of the form of the distortion. Of another case he says: "The final pale green segment at the last moment freed itself from the horizon, and for a second there still remained visible a faded green, washed out circular disklet, diameter perhaps 4'." This is the inverse of the appearance to Le Gentil of the sun "as if from chaos", and indicates that this sunset was of the same type A; my table of colors, etc., Table 2, shows many instances of this sort. Of still another case he says: "The sun's disk sank extremely slowly, and seemed, so to speak, to hang on the horizon." Though the horizon was free, the green flash did not appear this time. The slow sinking of the sun was probably not imaginary, but seems to be a characteristic of type B sunrises and sunsets.

C. Mostyn (103) says:

"The best displays took place when the refraction near the horizon was of such a character that the sun assumed a balloon, or vase, shape as he came close to the sea line. When, on the contrary, the sun appeared flattened out in its horizontal diameter, the green ray was either entirely absent, or was seen only in an indistinct and uncertain manner." These two shapes described are the same as type A and type B respectively.

A. Carpenter (12) says:

"On two occasions, the 6th February and 1st March, the sun rose green from the sea horizon, and immediately passed into a narrow layer of mist or cloud. On emerging above this, there was another green flash immediately capped by a second layer of mist. Emerging again, there was a third flash, and then a fourth and fifth, as it passed through two more layers. The sun was considerably distorted . . . . As the horizon was cleared by the lower limb, there was the usual reflection or inverted cup appearance, and it was noticeable that the inverted cup appeared to be raised partly out of the water. What was particularly remarkable was that this inverted cup appearance was reflected by each layer of mist or cloud in turn, as the lower limb rose above it. I found that this reflection on the water remained visible only some 6 or 8 seconds . . . . ."

Finally, an unnamed lady observed at Trieste (175) that "the last visible portion transformed itself into a flattened green disklet, which seemed to float on the surface of the sea." This again reminds one of Le Gentil's observation, and is a definite type A ending.

In my own table of observations, Table 2, it will be noted that in all the cases where there was observable a definite colored flash or spot or line at the end of sunset or the beginning of sunrise, the type was A; except No. 42, seen from the Baguio Observatory, at the rather critical elevation of 1500 meters, where there is the boundary above of a permanent haze layer, and the seat of remarkable refraction effects; and the sunset of Sept, 3, on the lee side of Hawaii. I was unable to assign to No. 42 any definite type form. There was no doubt about Sept. 3.

Writing from memory, in all the numerous definite type B sunsets observed at Manila before I began to note the final colored ray, there seems to have been always a line of yellow color at the end, not blue or greenish. The two type B cases at Woods Hole, Nos. 61 and 66, were orange and yellow lines at upper contact, respectively. And Capt. Carpenter (13) says that in numerous cases where the flash failed the sun rose red or gold or white from the sea.

Not only the sun, but also the brighter planets sometimes set green in the sea, as stated by Admiral J. P. Maclear (82) and by R. T. Mallet (83). W. F. A. Ellison (41, 42), using a four-inch equatorial, saw Jupiter vanish behind "the sharply cut skyline formed by the ridge of the Blackstairs Mountain" . . . . "the elevation was 1° 44′," . . . "As it passed below the skyline it was sharply divided by the prôfile of the mountain ridge for two or three seconds, and the last ray of light seen was a flash of bright bluish green" . . . The seven passengers on the *Saint-Laurent* (176) write:

"Today, Jan. 7, at 7 1/2 P. M., en route from Santander to Martinique, in latitude N. 20° and longitude W. 57°, we saw the setting of the planet Venus, thanks to a sky marvelously pure, and we state that at the precise moment when the planet disappeared below the water, it projected to us a magnificent green ray.

"Our statement gains in value since the undersigned were divided into two groups, one forward on the ship, the other aft, and had never conversed together on the question of the green ray."

Perhaps the most interesting account of this sort is that of the astronomer J. Evershed (44):

"I have one more observation to add to those described by Mr. Whitmell, and this will, I think, give the *coup de grâce* to the theory of a subjective effect due to retinal fatigue. In May, 1900, I happened to observe the setting of Venus in the sea from my eclipse camp on the Algerian coast. Observing with a 3-inch inverting telescope I saw the planet when very near the horizon suddenly change in color from dull red to vivid green, and as I lowered the telescope to the point where the sea horizon about bisected the field of view I was amazed to see two green images of Venus, one, the normal image, ascending from below,

and the other sloping down from above. This was probably reflected from the sea itself. The setting took place at the moment of meeting of these two images. The whole apparition, from the moment when the colour changed from red to green to the instantaneous disappearance of the two images, cannot have lasted more than four or five seconds . . . . "

Such an observation, by an experienced astronomical observer, deserves great weight. The suddenness of the transition from dull red to vivid green, and its occurrence probably simultaneously with the appearance of the mirage image, are to be noted.

I would conclude, then, that all the evidence indicates the following to be the conditions necessary for the green flash at the sea horizon; a reasonably clear atmosphere, a free water line, and conditions in the lower air near the water such as produce the common "mirage over warm water", to use Forel's term. Table 1, of colors of the sun compared with the final flash, (see "Alpha Ceti", G. N. Clarke, H. Crew, F. M. Exner, Flöckher, W. Groff, H. Metcalfe, A. W. Porter and A. Cowper Ranyard,) shows that even a deep redness of the sun is no bar to a final green flash. My own telescopic observations indicate that when the lower air boils and flimmers much, the final, or initial, spot may be so mixed and speckled that the green and blue and yellow may together produce no particular impression of color on the naked eye. Sunset No. 63 was a very good illustration of this.

Assuming mirage conditions, the estimates of A. A. Nijland, W. Goodacre and A. Carpenter, quoted above for the width of the green segment, may be reduced to about 2/3 of their values; as part, less than half, of the segment seen is the reflection of the rest.

The various difficulties of the simple dispersion theory of the "green flash," and the anomalous dispersion theory of W. H. Julius (61), are alike mostly disposed of in the latest contribution to the subject, by A. Danjon and G. Rougier (35). After describing the facts, they proceed:

"A great thickness of the terrestrial atmosphere absorbs the violet and the blue. Atmospheric dispersion giving a spectrum extending vertically, the green occupies the upper end and disappears last.

"The second theory has recourse to abnormal dispersion. Objecting to the preceding, which leads to durations too short for the observed facts, Julius supposes that the green ray is due to light abnormally dispersed in the neighborhood of the telluric lines of the solar spectrum..

"In fact, the green ray is not limited to the very brief phenomenon visible to the naked eye; in cases favorable to its production, there is seen with the telescope during the last ten minutes a green fringe bordering the upper half of the solar disk."

After describing the passage of irregularities in the limb, which slide upward and, detaching themselves from the fringe, often remain isolated for some seconds[1], they say that the lower limb is bordered

[1]Rather long, by my experience.—W. J. F.

with a dark red fringe, and everything happens as if the sun were formed of two nearly monochromatic disks, red and green, the green slightly above. "The green ray appears to the naked eye from the moment when the red disk has set; it lasts until the green fringe also is gone; but it is possible to study it with a telescope and to photograph it several minutes previously."

The apparatus used was mobile in altitude and azimuth; it consisted of a very brilliant spectrograph, lens 50 cm. focal length, flint prism of index 1.75, but very transparent, with a collecting lens of 52 cm. focal length projecting an image of the disk on the horizontal slit, which was always kept tangent to one of the fringes. Two minutes exposure of Wratten plates was sufficient. All the plates show three spectra, one of each fringe and one of the center of the disk, for comparison; these were made at the same elevation, as low as possible.

"The results, which will be given in a more detailed memoir, are clearly in favor of the normal dispersion theory. The spectrum of the green ray does not differ from that of the setting sun except in the suppression of the red, separated by atmospheric dispersion; on the other hand, the lower fringe comprises the red only, for the same reason. It is impossible to detect the action of abnormal dispersion, although the telluric lines are numerous and sharp on our plates; the appearance of these lines is exactly the same in the spectrum of the green ray and in the comparison spectrum."

The question is thus settled; then, as to Julius' objection, that the duration often exceeds two seconds, while calculation gives at most only some tenths. Along a ray there are notable fluctuations of index, shown by irregularities in the sun's limb near the horizon, not necessarily the same for rays of different colors leaving a single point of the sun's surface and arriving at the eye, since such rays may follow distinct paths. "So we see, for example, that the green fringe will have an abnormal extent, if the obstacle behind which the sun disappears is surmounted by a layer of air whose index increases upward . . From this there results a momentary widening of the green fringe, and the change in color of the final rays takes place early as compared with the theory, although the interval between the settings of the different colors may not be changed. So the green ray appears higher up, shows greater brilliancy and lasts longer than according to the simple calculation. This explanation is not purely hypothetical; it takes account of certain details noted through the telescope at the moment the green ray appears . . . . .

Finally, why is the green fringe so sharply limited, without color transition to the rest of the disk?[1] Here absorption comes in; the spectrum of the setting sun is rendered discontinuous by Brewster's bands, which are then very wide and dark. The rain band entirely suppresses the orange; the yellow is reduced to a very luminous but very narrow band, separated from the green by the bands α' and δ.

[1]See the description of Venus setting, by J. Evershed, above.

The yellow on the whole contributes little light, so that the spectrum is practically reduced to a red region and a green region. Further, the green ray is more easily observed when Brewster's bands are more intense.

The fringe is sometimes bluish, sometimes markedly blue, (Thollon at Nice). These variations follow those of the diffusion of the air and its dust, which especially affects short wave lengths. When the horizon was very milky, we were able to observe the disappearance of the whole spectrum except the red.[1] The green ray was quite unobservable.

At the sea shore the conditions favorable for these observations are most likely to coincide. But the sea is not necessary, though long so believed. We have often seen the green ray in Champagne since 1914, and the present work was carried out on the platform of the cathedral at Strasbourg, at the time (spring of 1920), when the sun set behind the gap of Saverne."

Bibliography of the "Green Flash."

The following bibliography contains all the references on the subject in periodical literature that I have found informing; while some of interest may be omitted, that may be in part due to the scrappy nature of the extremely scattered references, few of which are of such length as to be included in the great general catalogs of scientific literature. Consequently recourse had to be taken to the files of periodicals themselves, and search was made for certain key words in the general indices, or, lacking such, in the volume indices, or even in the weekly or monthly indices, of the periodicals which are listed here, in alphabetic order of the abbreviations used.

The numbers in parentheses after the names indicate the latest volume, etc., consulted.

In the bibliography, * means, reference not read, but may be of interest.

For library courtesies showed me I have to thank Fr. J. Comellas, of the Manila Observatory; the Library of Hawaii; Dr. L. H. Daingerfield, of the U. S. Weather Bureau, Honolulu; Prof. G. C. Comstock of the Washburn Observatory; the Boston Public Library; Prof. A. G. Webster of the American Academy of Arts and Sciences; the Librarian of the Academy; the Librarian of Harvard College Library; and Director Bailey of the Harvard Observatory.

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	Annales de l'Observatoire de Nice, (to date.)
Ann. d. Hydr.	Annalen der Hydrographie, u. s. w., (47.)
	Astronomy and Astrophysics, (Gen. Ind. 3.)
Bull. Soc. Astr. Fr.	Bulletin de la Société astronomique de France.
C. et T.	Ciel et Terre, (34.)

[1]Compare A. Rambaut, (123), p. 45.

C. R.	Comptes Rendus., Académie des Sciences. (Gen. Ind. 1895.)
E. M.	English Mechanic and World of Science, (110.)
J. B. A. A.	Journal of the British Astronomical Association, (30.)
Kn.	Knowledge, (1-26, n. s., 1-13.)
L'Astr.	L'Astronomie, (13.)
La N.	La Nature, (Gen. Ind. 1873-1912; 1920 II.)
Mem. Soc. Spett. Ital.	Memorie della Società degli Spettroscopisti Italiani, (1-24, 25-38.)
Met. Ztschr.	Meteorologische Zeitschrift, (36.)
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PROPOSED PERIODS IN THE HISTORY OF ASTRONOMY IN AMERICA.

By W. CARL RUFUS.

We propose to divide the history of astronomy in America into periods to facilitate further study of the subject. In order that the work may contribute to the desired end we must state the purpose of a systematic study of the subject, propose a method of division that offers advantages in realizing the purpose, and apply the method to the subject matter already at hand.

The primary purpose of the study of the history of astronomy in America, as herein conceived, is to establish a systematic account of the origin and development of astronomical ideas in America, giving full credit to imported ideas, but placing special emphasis upon American contributions. Closely related to the main purpose are the correlation of the chief movements of astronomy in America with similar movements abroad, their articulation with broader movements of science at home and abroad and their connection with the general progress of civilization. The importance of the ascertainment of facts, however, must be recognized as fundamental, like the accumulation of raw material. The oft-repeated illustration of a stately edifice, pre-existing in the mind of the architect, needs correction at one point. The selection of material is pre-determined by the plan of the architect; the true historian must use every ascertainable pertinent fact. First then comes the accumulation of facts, to be sorted, sifted, refined if necessary, but not one to be rejected. Provisional blue prints, like the present proposed outline, must be subject to revision, in order that the growing structure may reveal, not the pre-conceived plan of the architect, but the harmony inherent in the ideal edifice where truth resides.

In the main purpose of the study of the history of astronomy in America along with the accumulation of facts should be emphasized the organization of material in accordance with the provisional plan. The difficulty of selecting a basis for unity of treatment is recognized by every one who has attempted such a task. In this day of insistent demand that science must serve the nation, one is tempted to propose as a central theme, the service of astronomy to America. Material abounds for the development of such a plan. We may take, for example, the role of astronomy in the discovery of America. Astronomy contributed largely to the preparation of Columbus for his task and to the technical equipment for his voyage. The importance of the ascertainment of pertinent facts for immediate application in a study of this nature also receives due emphasis. Though such a plan appears attractive we fear it would prove to be artificial. To escape that danger we must look for a unifying theme inherent in the work. Unity of treatment must be secured, therefore, by tracing the genesis and growth of as-

tronomical ideas sought for their own sake, for the pure love of science and the true joy of finding. Then the work of each individual finds a harmonious place in the growing structure and each personal contribution will adorn the final product.

Many incidental benefits may be expected to arise from an observance of the secondary purposes. Articulating movements in astronomy in this county with similar movements abroad calls attention to the international character of the subject and illustrates the advantages gained by cooperation. Correlation with movements in other sciences shows the value of the interchange of ideas and the interdependence of cognate sciences. In this way the need of team work on a broad scale, international and interscientific in is scope, is recognized. Astronomy has led the way in the organization of international forces for scientific work, and has thus contributed to world unity. Relating to world progress lifts the individual task or achievement to a higher plane enhancing its value; and at the same time leaves no room for pride of achievement, which is so fatal to scientific work. It would seem therefore from these various considerations that such a study tends to teach the value of mutual dependence and mutual helpfulness, essential factors in the spirit of democracy toward which the nations painfully plod.

Any method of organizing the subject matter into an articulate story of the progress of astronomy in America faces the question of analysis as well as synthesis. How shall the subject be divided? Any historical account requires due recognition of a chronological order, within which a variety of methods of treatment may be employed. Thus the division into time periods demands first consideration. We summarily dismiss any plan for division by centuries, half-centuries or decades and all other plans imposed from the outside.

A brief study of the history of astronomy in America reveals the chief movements that have marked the extraordinary progress of that venerable science in the new world. These movements characterize various epochs or stages in the development of the science and provide a means of dividing the subject into periods as a basis for further study.

The attempt to outline the proposed periods on this basis meets with difficulties. Occasionally political or social events cast their shadow upon the dial of scientific progress and provide a rough means of determining and characterizing corresponding epochs, as the stationary period of the medieval age and the scientific revival of the Renaissance. Sometimes an important event occurs in science, like the invention of the telescope, which opens the way for a new period of discovery; or it may be the statement of a new far-reaching law, like Newton's law of gravitation, which marks the conclusion of a long period of induction and provides a basis for new activity. Such events, political or scientific, are not isolated occurrences; their origin lies in the ancestral past and their end fashions the future. Thus it appears

that an epoch-making event suitable for a beginning or an end may seem better adapted to serve as the center of a movement.

Origins or starting points, however, have special value in the interpretation of scientific progress. New laws and principles, like nascent elements, seem to possess extraordinary virtue, producing new conditions and instituting new movements. The beginning of such a process of change or development affords the best opportunity to study its fundamental principles and leading characteristics. Consequently we shall follow this clue in the proposed outline, giving special attention to the rise of the chief movements as a basis for the division of the subjects into periods. In this way the force of the new movement will determine and characterize the period until another new force arises. We may expect to find, however, that the old forces continue to act and the old movements remain uninterrupted, although new ones occupy the center of the stage.

The general rule for the division into periods must not be applied too rigidly, nor should the dividing lines that mark the periods be drawn too sharply, lest they violate the purpose they should serve. Paradoxical as it may seem, history is divided into epochs in order that its unity may be more evident. Epochs are not severed segments of the thread of human history; they are links in the chain of progress. Their function is to unite rather than to divide. So the periods suitable for our subject may appear to overlap beyond our power to extricate; but they will serve our purpose if they assist in preserving the continuity of the story of the progress of astronomy in America. Perhaps this can best be accomplished by outlining the periods approximately, permitting some to be influenced by political events, without attempting to fix the limits too exactly, adopting decennial dates in general instead of year, month and day, and by keeping in mind constantly that each period depends upon its predecessors for its initiation and reaches completion by establishing a vital relationship with its successor.

Another word of explanation seems necessary before the proposed periods are presented. In this pioneer work no attempt has been made to find parallel periods in the history of other particular sciences or of science in general in America. The author confesses too great ignorance of the broader field, which is still in its infancy, to attempt such a comparison. Moreover, the contributions from each special field should depend upon and be determined by the achievements within the field rather than by influences from without. Too great reliance has not been placed upon opinions expressed in articles written to cover special phases of the subject. Consequently equal privilege is cordially extended to others to accept or to reject the periods proposed in this paper. Co-operation, including friendly criticism, is necessary to accomplish an acceptable work. Since astronomy is a pioneer subject by nature we may expect to find that other branches accompany or follow its lead. It is the hope, therefore, that the proposed periods in the history of astronomy in America will shed some light on similar questions in other fields.

Proposed Periods in the History of Astronomy in America.

Introductory Period, 1490-1600.	Colonial Period, 1600-1780	Apparently Stationary Period, 1780-1830.
		Beginning of *Mathematical Astronomy* Nathaniel Bowditch; Translation of Mechanique Celeste, completed 1817, publication 1829—.
The second page of the chart belongs to the right of this page.		Plans for observatories; National, F. R. Hassler, J. Q. Adams. Harvard; John Lowell, W C. Bond, Corporate action 1815.
		Astronomical contributions to American Phil. Society, American Academy of Arts and Sciences, American Jour. of Science.
	Beginning of *Observational Astronomy* Thomas Robie. John Winthrop. David Rittenhouse. First observatory. Transit of Venus.	Observations; Eclipses, comets, Mercury's transits, Jupiter's satellites. Samuel Williams, John Lukens, D. Rittenhouse. Dorchester observatory, W. C. Bond, about 1823.
	Teaching of Astronomy Theologues as tutors. John Winthrop, Hollis Professor, 1738. Nehemiah Strong. "Astronomy Improved", 1784.	Rising generation of future astronomers; Yale, West Point, Harvard. "An Elementary Treatise on Astronomy", John Farrar, 1827.
	Development of American scientific consciousness: Franklin, Junto. American Philosophical Society, Amer. Academy of Arts and Sciences.	Interest of statesmen; Washington, John Adams, Jefferson, J. Q. Adams. American Journal of Science, 1818.
Application of astronomy in *Navigation*.	Navigation schools; Capt. Woodbury, B. West. Thos. Godfrey (below).	"Practical Navigator", Bowditch. Coast and Geod. Survey.
In the discovery of America, Columbus. In exploration and settlement, Thomas Hariot, 1585.	Astronomy in surveying; Jacob Taylor, Mason and Dixon. Almanacs; S. Danforth. Taylor, Ames, Franklin.	Public land surveying; Andrew Ellicott, Jared Mansfield. U. S. Almanac, Thomas' Almanac.
In equipment; Tables of Regiomontanus, The improved astrolabe of Behaim; Compass, cross-staff, "perspective glass", spring clocks.	Inventions: reflecting sextant, Godfrey, 1730; collimator, David Rittenhouse. Independent discovery of use of spider threads, making of instruments and orrery, Rittenhouse.	Beginning of telescope construction in U. S. Amasa Holcomb. Making of instruments, Benjamin Rittenhouse. Chronometers, W. C. Bond.

1830-1860.	1860-1890.	1890-
Theory of Neptune, Moon, Saturn's rings; B. Pierce. Neptune theory, Walker. Tides, William Ferrel. Meteors; D. Olmstead, Twining, Herrick.	Theory of Uranus, Neptune, Moon; Newcomb. Lunar theory, G. W. Hill. Meteors and comets, Daniel Kirkwood, H. A. Newton.	Newcomb; Planetary theory, Astronomical Constants. E. W. Brown, Lunar Theory. F. R. Moulton, Planetesimal hypothesis.
Rise of observatories; North Carolina, Williams, Western Reserve, Philadelphia High School, West Point, Dana House —.	Dearborn 18″ refractor, '62. H. Draper 28″ mirror,'70. Naval 26″ refractor, '73. Lick 36″ refractor, 1887. Spectroscopic equipment.	The construction of large instruments; Lick, Lowell, Yerkes, Ann Arbor, Mt. Wilson. Southern stations.
Sidereal Messenger, 1846—'48, O. M. Mitchell. Astronomical Journal, B. A. Gould, 1849-'61, '86— Astronomical Notices, '58-'62, F. Brunnow.	Observatory publications, Naval, Harvard. Sidereal Messenger, 1882-1891, W. W. Payne. Astronomical Journal resumed, 1886.	Astronomy and Astrophysics, 1892-'94. Popular Astronomy, 1893-. The Astrophysical Journal, 1895-.
American discoveries: Comets; return of Halley's, div. of Biela's, one by Miss Mitchell. Hyperion; W. C. Bond,'48. Saturn's dark ring; G. P. Bond,'50; Asteroids.	Aster.; Watson, Peters. Sirius dark companion, A. G. Clark, 1862. Mars' satellites, Hall,'77. Double stars, Burnham. First spectroscopic binary, E. C. Pickering, '89.	Satellites: Jupiter; 5th, Barnard, 6th and 7th, Perrine, 9th, Nicholson. Saturn; 9th and 10th, W. H. Pickering. Double stars; Aitkin, Hussey.
Numerous elementary texts; Olmstead, W. A. Norton. American editions of Herschel's Astronomy. Practical Astronomy; Elias Loomis, J. Gummere.	Astronomy in graduate schools. Chauvenet, Spherical and Practical Astronomy. Watson, Theoretical Astronomy. C. A. Young, texts.	Practical Astronomy, W. W. Campbell. Celestial Mechanics, F. R. Moulton. Union of teaching and research.
The National Institution for the Promotion of Science,'40, succeeded by American Association for the Advancement of Science, '50. Smithsonian Institution.	National Academy of Sciences, 1863. Astronomical Society of the Pacific, 1889. International cooperation, Paris conference, 1887.	Astronomical and Astrophysical Society of America, '99, succeeded by American Astr. Society. Internat'l. Solar Union. International Astronomical Union.
Naval Observatory, 1844. Sumner's method, 1843. Naval expeditions.	Naval expeditions; eclipses, transits of Venus. Cartography.	Eros campaign. Radio time service. Radio distance finder.
Coast and Geodetic Survey reorganized, 1832. Bache, 1843. Nautical Almanac, 1849.	Corrected long. difference, Greenwich-Paris. Transcontinental arc. Earth form and size, Pierce, Hayford.	Field transit micrometer. U. S. Standard Dictum, '01, made North American Standard Dictum, 1913.
Talcott, zenith telescope. Invention, chronograph. (Amer. method of lat. & long. determination.) Instruments; Wurdemann, Draper, Rutherford, Fitz, Clark, Spencer.	Inventions: Meridian photometer, E. C. Pickering; almucanter, Chandler; Bolometer, Langley; Spectroheliograph, Hale; Ruling gratings; Rutherford, Rowland.	Spectroscope improvement; Allegheny, Lick. Interferometer and gratings, Michelson. Instruments: Clark, Brashear, Spencer, Warner and Swasey, Ritchie.

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Popular Period, 1830-1860.	New Astronomy Period, 1860-1890.	Correlation Period, 1890-.
		Beginning of *Quantitative Astrophysics*
		Radial velocity: Stars; Lick, Yerkes. Nebulae, Keeler, 1890.
		Spectroscopic binaries; E. C. Pickering, 1889. Frost and Adams. Campbell, catalogues.
		Parallax by spectroscope, Adams.
		Stellar radiation; Coblentz, Stebbins.
		Astronomical measurement by interferometer, Michelson.
	Beginning of *Astrophysics*	
	Classification of stellar spectra: L. M. Rutherford, Henry Draper, E. C. Pickering.	Draper Catalogue, 1890. Henry Draper Cat. 1918-. Quantitative method of classification, Adams. Correlation of spectral class with velocity; Campbell, Kapteyn, Boss.
	Evolutionary sequence; Pickering, Hale.	Russell's theory. Branching of sequence.
	Solar Physics; Reversing layer, Young. Normal spectrum, Rowland. Solar constant, Langley.	Magnetic field in sunspots, Hale. Solar constant, Abbot. Correlation solar with terrestrial phenomena.
	Photometry, Pickering. Variables, Chandler.	Selenium cell and photoelectric cell photometry.
Beginning of *Practical Astronomy* James M. Gillis, S. C. Walker, J. H. Coffin, J. S. Hubbard.	Uranometria Argentina, B. A. Gould. Meridian astronomy. Latitude variation, Chandler. Parallax; Elkin, Hall.	International cooperation in A. G. catalogue; Dudley, Naval, Harvard. Preliminary General Catalogue, Lewis Boss.
Popular interest: Yale 5", 1830; eclipse, '31: star shower, '33; Halley's. Lectures, Mitchell. Local astr. societies.	Popular interest in astronomy and in science in general interrupted by war. Astronomical bequests.	Interest of men of wealth; Lick, Yerkes, Hooker. Cooperation of industry and science.
Pioneer astronomical photography: J. W. Draper; ultraviolet, 1837, Moon, 1840. Rutherford, G. P. Bond.	Photography of stellar spectra, H. Draper, '72. Stars, nebulae, Milky Way; Barnard.	Photographic discovery; Comets, asteroids, novae, variables. Planetary photography. Parallax, Schlesinger.

The main features of the chart of "Proposed Periods" are readily seen. Beginning at the left and near the bottom is the Introductory Period 1490-1600. Each period to the right increases in height one step for the introduction of new movements in astronomy in America. Any movement, e. g., the rise of observational astronomy, which occurs in the Colonial Period may then be traced toward the right through all the following periods and the most important American contributions are indicated. In general continuity is preserved by movement toward the right and the expansion of the subject by the increasing height, so progress is revealed in a two-dimensional form. To correlate with other movements, e. g., the development of astronomy in Europe, a horizontal space may be added at the bottom of the chart.

At this time we are chiefly concerned with the new movements in astronomy in America or the outstanding features that determine and characterize the periods. In succession the proposed periods are,—Introductory 1490-1600, Colonial 1600-1780, Apparently Stationary 1780-1830, Popular 1830-1860, New Astronomy 1860-1890, and Correlation 1890—. Carrying out our architectural analogy we may give a metaphoric interpretation. 1. *Selecting a site.* This includes the period of discovery and exploration. 2. *Preparing the way.* Colonization preceded a beginning in observational astronomy, the only work in astronomy for its own sake during this period. 3. *Laying the foundation.* Establishing the new republic interrupted scientific work. Bowditch, however, quietly and unostentatiously, but with painstaking perseverance, did fundamental work in mathematical astronomy, laying the foundation for the strong school of American mathematical astronomers. 4. *The first story.* A popular wave swept the country, accompanied by the rapid rise of observatories and the first important American discoveries in astronomy; while Gilliss assiduously recorded transit observations and established the first observatory for practical astronomy in the United States. 5. *The rising structure.* Great progress was made in all branches of astronomy during this period, which was characterized chiefly by the rise of astrophysics. 6. *The towering edifice.* America reaches preeminence in the field of astronomy excelling in the construction of large observatories; but the distinctive feature of the period is the introduction of quantitative methods in astrophysics, making possible the work of correlation among the various branches.

We shall now attempt to justify the selection of the proposed dates. A full and complete treatment of the subject would involve a detailed application of the entire analytical process, which the space limit prevents. Only the most definitive features may be presented. Greater attention to details will be given in the early periods.

We frankly confess that the introductory and colonial periods are not determined primarily by astronomical considerations alone. The fact appears to be that astronomy for its own sake was not seriously cultivated in the colonies until after the beginning of the eighteenth cen-

tury. In the wilds of the new world men had stern tasks to perform, which left them little time to devote to science. There were forests to fell, to clear the land for cultivation, and to obtain timber to palisade against the ravages of the red man, rightful claimant of the land. There were roads to build, rivers to bridge and mountains to cross in the trek of civilization. Furthermore, new political, social and religious problems clamored for solution in a virgin soil. We must look, therefore, to the daily life of the pioneer and to the common task of the colonist, for the first indications that astronomy was taking root in America. For this reason we make political events definitive in the earliest periods, also taking into consideration the chief applications of astronomy affecting American life and emphasizing the first glimmerings of the true scientific spirit manifested in the astronomy of the new world.

The Introductory Period, 1490-1600. Astronomy played an important part in navigation during the period of discovery and world-wide exploration. We have already mentioned its role in the discovery of America. Columbus believed the astronomical doctrines of the sphericity of the earth and its relative smallness, and concluded that he could reach the east by sailing west. In addition to the primitive compass, the cross-staff and the medieval portolano, his equipment for the voyage of discovery probably included the tables of the great astronomer, Regiomontanus, and the improved astrolabe of Behaim for determining position at sea.

Thomas Hariot, English mathematician and astronomer, accompanied a band of colonists sent out by Raleigh (the second expedition to Virginia) which settled upon Roanoke Island, North Carolina, 1585, and remained about one year. This accorded with the custom of the time, as a scientist frequently was selected and sent out with an exploring or colonizing party. Hariot afterward wrote, "A Brief and True Report of the New Found Land of Virginia." His function was that of "discouverer" and his equipment included mathematical instruments, a sea compass, a loadstone, "a perspective glass whereby was showed many strange things," and spring clocks. During his stay in America he recorded the observation of a comet.

The year 1600 may be taken as an approximate dividing line between the century of discovery and exploration following Columbus and the succeeding colonial period.

The Colonial Period, 1600-1780. Astronomy was cultivated in the new world during early colonial days chiefly for its application in the making of almanacs, in land surveying and in navigation.

The first book issued by the first printing press in America, 1639, was "An Almanack, Calculated for New England by Mr. Pierce, Mariner." No copy is extant as far as known. The number of almanacs increased rapidly and the contents multiplied. To the calendar and list of eclipses were added solar, lunar, and planetary data, astrological predictions and weather forecasts. Later were included proverbs, jests, hu-

morous stories, wise sayings, history, medicine, politics and science; so the original calendar became a compendium of universal knowledge. Samuel Danforth was the first colonial almanac maker of special note. Jacob Taylor, a colonial surveyor, prepared the astronomical calculations for an almanac published from 1702 to 1746. Nathaniel Ames neglected his medical profession to study the heavens and to make calculations for his popular production, "An Astronomical Diary and Almanac." His work just preceded "Poor Richard's Almanac," which became more famous, although Tyler (History of American Literature) considers that the annual of Ames excels Franklin's in many respects. "Poor Richard's Almanac" was the first American publication that broke through colonial boundaries. Scraps of wisdom, satire, and keen sallies against rival almanacs constituted its chief merit.

Among other names connected with early almanac making are John Winthrop II, Oakes, Cheever, Chauncey, Brigden, Flint, Dudley, Holyoke, Clough, Sherman, Brattle, Cotton Mather, Nathaniel Mather, Strong, Travis, Green and Tulley. Benjamin West's almanacs contained more than the ordinary amount of astronomical information.

Surveying became important in determining proprietary rights and fixing colonial boundaries. Jacob Taylor, previously mentioned, was one of the first of a long and honorable list of colonial surveyors including college professors, ministers, practical astronomers, state officials, and two future presidents of the United States, Washington and Jefferson. Mason and Dixon, Englishmen, were sent for in 1763 to settle a boundary dispute between Pennsylvania and Maryland. Trained under Bradley at the Greenwich Observatory, Mason was a skilled observer. They transmitted to the Royal Society of London the measurement of an arc in latitude 39° 12′ north, thus contributing to the solution of the problem of the form and size of the earth. They also considered the variation of gravity from Greenwich, made lunar eclipse observations and observed phenomena of Jupiter's satellites. Their work was interrupted by the hostility of the Indians, who at an earlier date, 1709, resented encroachment upon their territory by burning at the stake Lawson, Surveyor-General of Carolina, and as late as 1782 the Sandusky Indians similarly tortured to death Colonel William Crawford, also engaged in surveying. David Rittenhouse of Pennsylvania carried out extensive surveys and might have qualified for the work of Mason and Dixon, but outsiders were deemed desirable to settle the long-standing dispute. Other surveyors are Cadwallader Colden, Andrew Porter, Joseph Neville, John Lukens, Robert T. Paine, Thomas Hutchins, John Page, Thomas Lewis, Andrew Ellicott, and Jared Mansfield.

Thomas Godfrey of Philadelphia invented the reflecting sextant in 1730 and it was applied in navigation during the same year. A year later Hadley in England was credited with a similar invention, which may have originated in Newton's drawings and description of such an instrument in 1700. Navigation schools contributed to the interest in

astronomy and secured at least one patron of the science, Benjamin West of Rhode Island.

The early colonial colleges included astronomy in their curricula. At Harvard it occupied a place in the last quarter of the last year, a crowning feature of the college course. The quality of the instruction, however, does not appear to have corresponded with this exalted position. Any educated theologue was considered to be eminently qualified to teach mathematics and astronomy. Gassendi's Astronomy, which antedated Newton's greatest contribution to science, was used in Harvard and in Yale fifty years after the publication of the Principia. In 1738 John Winthrop became Hollis Professor of Mathematics and Natural Philosophy at Harvard and introduced Gravesand's Philosophy, which taught Newtonian principles. Nehemiah Strong, Professor of Mathematics and Natural Philosophy in Yale, expounded the law of gravitation and its application in planetary problems. Three lectures given in 1781 were printed in 1784 under the title, "Astronomy Improved." The salutary effect of astronomical teaching in dispelling astrological notions and colonial superstitions may easily be seen in this movement among the colleges, especially through the influence of "preacher astronomers."

Observational astronomy in America began early in the eighteenth century. The first observations to attract attention were made by Thomas Robie. Immersions and emersions of Jupiter's satellites were observed in 1717 and the longitude of Harvard west of Upminster was determined. He also observed solar and lunar eclipses with his "eight-foot telescope" and communicated his results to the Royal Society of London.

John Winthrop, Professor of Mathematics and Natural Philosophy of Harvard, observed the transit of Mercury, April 27, 1740, with a 24-foot telescope. The unstable mounting and a disturbing wind gave some difficulty, but his data were published by the Royal Society. In 1761 the "Province Sloop" was provided at public expense to transport Winthrop and party to Newfoundland to observe the transit of Venus. The solar parallax determined gave a low value, 8″.25, later revised by Winthrop including all available data and increased to 8″.68. His work on the transit of Venus in 1769, observed at Cambridge, also gave rather poor results. However, his various observations on eclipses, earthquakes, sunspots, meteors, comets, lightning, aberration of light and variation of the magnetic needle, together with numerous scientific contributions, establish his priority as the greatest scientist of the colonial period and America's first astronomer.

Surpassing Winthrop in mechanical ingenuity and observing skill came David Rittenhouse, a self-made astronomer, a real product of American genius and toil. In his farm shop at Norriton, Pa., he manufactured clocks, constructed a celebrated orrery purchased by Princeton and made various astronomical instruments. This place was selected by the American Philosophical Society as one of the three sites

for the observation of the transit of Venus in 1769. Rittenhouse made the preliminary calculations for the transit, determined the latitude and longitude of the station, rated the clocks, and looked after the necessary details. Data obtained by the Norriton station combined with Greenwich data for the same transit gave a determination of the solar parallax, 8".805, in striking accord with the present adopted value, 8".802. Rittenhouse moved to Philadelphia where he erected an observatory about 1782, a small octagonal building of brick in the garden adjacent to his residence. The Revolutionary War interrupted plans to erect a large observatory in Philadelphia with Rittenhouse as first director. Lord North, prime minister of England, and Maskelyne, the astronomer royal, were solicited for their cooperation in the project in 1775, but the war clouds were already gathering.

Other observers whose work deserves at least passing mention are Rev. Phillips Payson, President Joseph Willard (Harvard), Mr. Danforth, Mr. Appleton, Mr. Owen Harris, Benjamin West, Joseph Brown, Dr. William Smith, Hugh Williamson, John Lukens, Joseph Shippen, John Ewing, Owen Biddle, Joel Bailey, Richard Thomas, Thomas Coombe and Samuel Williams.

During the greater part of this period colonial science looked to England for its inspiration and courted the favor of the Royal Society as its patron. Benjamin Franklin deserves chief credit in the development of an independent spirit and in the creation of an American scientific consciousness. His Junto, 1727, a coterie of scientific friends, was the precursor of the American Society for the Advancement of Natural Knowledge, which he succeeded in organizing in 1743, although it had a precarious existence until its reorganization in 1769 under the name of the American Philosophical Society. In 1780, before the smoke of battle had cleared away and independence was assured by treaty, the American Academy of Arts and Sciences was incorporated with John Adams as chief promoter and many public men including George Washington as members.

A creditable beginning in astronomy was made during the colonial period. Godfrey and Rittenhouse exemplified the American trait of mechanical ingenuity; the former by the invention of the reflecting sexant, and the latter by the construction of instruments previously mentioned, the invention of the collimator, a device for establishing a meridian without a distant mark, and by the independent discovery of the use of spider lines in the focus of a transit instrument. Keenness of observational power was also displayed by Rittenhouse, who noted the entire circular outline of Venus when a part was off the sun and suggested an atmosphere of Venus, a fact that was verified a hundred years later by the observation of Lyman and subsequent explanation by Russell. Samuel Williams during a solar eclipse in 1780 noted "luminous drops," the phenomenon known as Bailey's beads from the description given by Bailey of his observations over fifty years later

in 1836. In general the early observers working under disadvantages, making the best of circumstances, striving after the highest quality of results with inadequate equipment, exemplified those indispensable characteristics essential for success in the quest for scientific truth.

The year 1780 is the decennial date that ends the colonial period.

(To be continued.)

ERATOSTHENES II.

By WILLIAM H. PICKERING.

Introduction.

Of the nearly one thousand known bodies, not counting the comets and meteor swarms, comprising our solar system, there are only three with whose solid surfaces we are at all familiar. These are of course our Earth, our twin the Moon, and the planet Mars. On each of these three, vegetable life exists, but strangely enough while its existence is now probably generally conceded on Mars, it is quite safe to say that the vast majority of astronomers would definitely deny it, perhaps we might say it is universally denied, in the case of the Moon. This at first seems odd, because the surface changes, by which it can alone be recognized, are much more readily seen on the Moon than they are on Mars.

The explanation is probably two-fold. As far as our terrestrial experience goes, vegetation always requires several days to develop after the seed is sown, or the ground is first warmed by the spring sun. The same is more or less true on the Moon; but this delay carries the region in question a considerable distance from the terminator, and no one examines the Moon excepting on the terminator itself. This is because the terminator is so much more beautiful than other regions, that they are for this aesthetic reason neglected, in spite of their interest. The other reason is less creditable to our intelligence, and to our application of the facts of history. It is the same old argument employed by the ancients, from the days of Aristotle to those of Galileo, and for which some persons have even gone so far as to ridicule them. Applying it to the present case, it may be expressed briefly as,—because owing to a plausible and generally accepted theory, life is believed to be impossible on the Moon, therefore it is unnecessary to consider the facts, which may safely be ignored. Life is therefore said not to exist upon the Moon. It would appear that human nature has not changed very much in 2000 years.

Let us now see what the great telescopes in the north might be expected to show in case they should be turned upon our twin planet. In our former paper, Eratosthenes I, POPULAR ASTRONOMY 1919, **27**, 579, we dealt with the surface changes which were shown by photography, and which were visible under favorable circumstances in a 3-inch telescope. During the months of January and February the atmospheric conditions of the temperate zone, with its westerly circulation and poor seeing, sometimes reach as far south as Jamaica. Also during the autumn, for a day or two before the arrival of a hurricane, or even sometimes preceding smaller storms with high wind velocities, our zenith seeing drops to 5 on the Standard Scale. Under these circumstances we find that although with our 11-inch aperture we are able to resolve closer double stars than with our 3-inch finder, yet as far as planetary definition is concerned, the two instruments are about equally effective.

At Harvard it has been found that between altitudes of 30° and 60°, 5 is the usual seeing throughout the year (H. A. **61**, 24). Therefore the drawings illustrating the above mentioned paper on Eratosthenes show about as much as we should expect to see with any telescope at Cambridge having an aperture of over 3 inches, whether it was 3 or 30. That is to say that is what we should expect night after night for a continuous investigation. On special favorable occasions of course somewhat more could be seen with let us say a 6-inch aperture. If we travel south-westerly over the lower Mississippi valley, we shall find that the seeing improves, and becomes as good as it is sometimes in England and in northern France. Observers located in these regions, and furnished with apertures of 6 inches and upwards, should be able to see more than the above mentioned drawings disclose. Finally when we get to the south-western states, Arizona and the southern portion of California, for a part of the year at least, the seeing is similar to what we have in Jamaica. Whether it is equal to it or not is unknown, because the seeing in these regions has never been measured throughout the year with a sufficiently large aperture such as has been employed here (H. A. **82**, 31). It is clearly not the fault of the northern observers that they cannot see more, and there is certainly nothing they can do to better their condition. At the same time it is not proper for them to declare erroneous or purely imaginary, as some of them are too apt to do, the observations of those working under more favorable circumstances.

The drawings illustrating this paper accordingly represent much more than can be seen at most observatories, although some of the coarser details should be visible even in New England. In a third paper it is hoped to discuss some of the very finest detail visible on the Moon with our 11-inch aperture. This is perhaps the most interesting and suggestive of all, but there is no room for it in the present article.

Vegetation can of course be recognized and identified as such, only

by means of surface changes. Someone may say that a surface change does not prove vegetation, it may merely indicate something else, which is entirely unknown to us. This of course cuts off all argument. We shall call the cause of the change, however, whatever it is, vegetation, and the word is to be understood in that sense. It may perhaps be worth while to repeat here what has been previously said, that dark markings visible at full moon cannot be due to shadows, and that changes visible near the center of the lunar disk cannot be due, as one astronomer has recently suggested, to libration.

A comparison of the three planets above mentioned leads us to affirm that four different kinds of seasonal change may occur upon them. The first is a color change. This in the case of a near hill is very conspicuous on the Earth. It is less marked in the case of Mars, and while perhaps probable is still uncertain, in the case of the Moon. The second is a change in surface brightness. This also is obvious in the case of the Earth, and also on the Moon, but less marked though certain in the case of Mars. The remaining changes may be said to be unknown on the Earth.

The third occurs only in the canals, and consists in a transverse shift, such as is described in our Report on Mars No. 23, POPULAR ASTRONOMY **29**, 4, where the canal slowly shifts over the surface transversely, areas which were at first light becoming dark, and areas which were at first dark becoming light. This occurs also on the Moon, and since the Moon is at only one two-hundredth the distance of Mars at an average apparition, the lunar change is more conspicuous, although the canals or runs are much smaller.

The fourth variety of change is characteristic of the Moon, although something of the sort has also been detected on Mars. It consists in a steady longitudinal growth or recession of the canal or dark area. While vegetation as a whole moves northerly or southerly with the seasons on both the Earth and Mars, it is in those cases clearly due to a change in temperature, or a change in moisture, over large areas of the region affected. On the Moon within a narrow restricted area, for instance inside of a crater, this does not seem possible, and it is not clear as to what can be the cause.

It is the writer's custom in making a detailed study of any lunar region, after obtaining what appears to be a satisfactory drawing, to make a tracing of it and to use that tracing for the next night's work. When many drawings are being made, as in the case of the present crater, the general outline, the more characteristic features, and certain standard positions, are printed on a number of blank sheets, and these are kept and used as required. By this means much time is saved in locating permanent outlines. Errors of drawing are also more readily detected and actual changes that occur from night to night, after checking at later lunations, are more easily recognized. Certain fixed markings, such as small details of the crater rim, are always necessary

as fundamental points of reference. The selection of a sufficient number of these suitably placed is often a serious difficulty, and an erroneous choice, such as the selection of a shifting detail, may lead sometimes to very discouraging results. For really accurate work many reference points are necessary, and their relative positions must in the first place be very carefully determined. This we shall readily understand when we consider that a single crater like Eratosthenes, only 37 miles in diameter, contains far more minute detail than the entire surface of the planet Mars. It will thus be seen that there is plenty of work in store for the selenographer of the future.

The best possible reference points are the smaller bright craterlets that are scattered all over the surface at lunar midday. Unfortunately, unless quite large, they are often visible for only a few days at a time, nor are there as many of them as we should like. Practiced judgment is required in selecting what other points are likely to be stationary. Indeed, instead of finding the Moon a dead unchangeable body, as it is usually regarded, we find that the continual shifts and changes taking place in certain of the lunar detail, after all the shadows have disappeared, present the chief difficulty to the selenographer who endeavors to sketch these features with accuracy.

Occasionally this is due to illusion. Thus the central peaks themselves may sometimes appear to change their location. This is due to the fact that at sunrise their western slopes are illuminated, and at sunset their eastern. The effect may be detected in the photographs of this crater published in Harvard Annals **53**, Plates II and IV, Figures 6 and 16. It will be noted that the culminating ridge of the central peaks appears to occupy the center of the crater in the former, and to have shifted distinctly to the right in the latter. Measures made with a millimeter scale show that this is not really the case.

The Snow on the Central Peaks.

It would seem natural to suppose that the bright areas often located on the central peaks would, like the craterlets, make excellent reference points, and it is obvious that on account of their central location they would be particularly useful for this purpose. For really accurate work however this is not necessarily so. This fact is well illustrated by the crater under discussion. When the sunlight first strikes its highest central peak, at colongitude 14°.6, the latter is very faintly illuminated. By 26° it has brightened to 5, and a crater 3500 feet in diameter has appeared in its summit. The interior of this crater rapidly brightens, and by colongitude 40° has reached 8.5. From then until 140° the brightness ranges from 9 to 10 after which it falls off to 8. This extreme brightness is doubtless due to snow rather than cloud, but until 50° this does not pass the crater walls. The crater is found however to occupy the summit of a fairly bright ridge extending in a nearly north and south direction, or in azimuth 192°. After colongitude 70° its brightness fades.

At 50° the interior snow begins to creep over the southeastern wall of the craterlet, soon extending 0″.5 or a little over half a mile beyond it. This is only what had previously been noticed in other craters, and so is nothing new, but on none of them had accurate measurements heretofore been made. These are now given for Eratosthenes in

TABLE I.

SNOW ON THE CENTRAL PEAK.

Colong.	1920	No.	Azimuth	Colong.	1920	Breadth	Length
50°.7	Dec. 21	4	114°.5	26°.4	Oct. 21	0″.65	0″.65
51.5	Aug 25	1	114.8	27.7	Aug. 23	0.6	0.6
61.4	Dec. 22	4	119.2	40.3	Aug. 24	0.55	0.55
65.0	Oct. 24	1	107.9	51.5	Aug. 25	0.55	0.65
70.1	Nov. 23	4	121.3	52.1	Oct. 23	0.55	0.55
76.4	Aug. 27	1	125.4	60.6	Dec. 22	0.65	0.95
77.2	Oct. 25	1	123.8	64.6	Oct. 24	0.7	1.1
81.1	Nov. 24	4	137.3	76.4	Aug. 27	0.5	0.65
85.6	Dec. 24	4	140.4	77.2	Oct. 25	0.65	0.8
86.6	Dec. 24	4	147.4	85.6	Dec. 24	0.6	0.8
89.3	Oct. 26	1	134.0	99.3	Dec. 25	0.7	0.9
99.3	Dec. 25	4	151.6	100.9	Aug. 29	0.45	0.7
107.3	July 31	1	152.3	133.3	Nov. 28	1.0	1.0
132.3	Nov. 28	1	155.5	143.7	Nov. 29	1.0	1.0
133.3	Aug. 2	1	148.3	149.6	Dec. 29	0.55	0.75
149.6	Dec. 29	4	153.8				
177.8	Nov. 2	1	178.8				

Table I, where the azimuth of the major axis of the snow referred to the line joining two bright craters, which is in turn referred to the Moon's axis, is given in the fourth column, and its breadth and length in the last two. These results are plotted in Figure 1, where the abscissas represent the colongitudes, and the upper ordinates the azi-

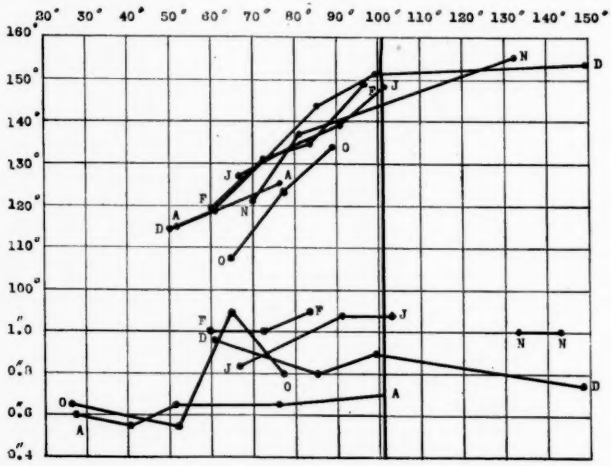


Fig. 1

SHIFTING OF THE SNOWS.

PLATE XVIII

FIG. 3
1919, Sept. 3, 9d, 20°2, 9

FIG. 4
1919, July 11, 19d, 81°9, 9

POPULAR ASTRONOMY, No. 287. DRAWINGS OF THE LUNAR CRATER ERATOSTHENES.

PLATE XIX

FIG. 5
1919, July 15, 18^{d}, 131°6, 11, 8

FIG. 6
1919, Oct. 13, 20^{d}, 150°1, 7

POPULAR ASTRONOMY, No. 287. DRAWINGS OF THE LUNAR CRATER ERATOSTHENES.

muths taken from the fourth column of the table. The lower ordinates indicate the length of the snow field including the crater, the results being taken from the last column. The observations made during the same lunation are connected by lines, and are indicated by the initial of the month during which they were obtained. The first ones began in August 1920 and the last were made in February 1921. The heavy vertical line indicates lunar noon, or the summer solstice of the crater.

The snow does not extend beyond the limits of the crater walls until after colongitude 50°, the upper graphs therefore begin at that point, and the azimuth at once begins to shift at the rate of 1° in two hours until colongitude 100° is attained. After that it remains practically constant. During December it remained consistently higher than during October by 12° to 15° at the same colongitudes. The smoothness of the individual curves seems to imply that this result represents an actual fact, and is not due to accidental errors. While the length of the snow field ranges in general only between 0″.6 and 1″.1, the contrast with the dark rocks on which it rests is sufficient, so it is believed, to make this observation capable of repetition by some of the northern observatories. Just why the snow should shift and revolve within the crater is as much of a mystery as why the clouds within many of the crater rims should brighten successively, clockwise in the northern hemisphere, and counter clockwise in the southern (POPULAR ASTRONOMY, 1917, **25**, 154). It is to be remarked that although Eratosthenes is in the northern hemisphere, the rotation of the snow is counter clockwise, or opposite to that required by the law for the clouds. The successive brightening of the clouds can be watched by anyone, and is much easier to observe than the changing position angle of the snow.

With regard to the length of the snow field, it would seem that if this is going to materially increase, it will occur shortly after colongitude 50°. We notice that in August there was no appreciable increase at all, while in October there was a very marked storm, or eruption, whichever we choose to call it. As the snow is well defined, the difference between a length of 0″.6 and 1″.1 is very marked in the telescope, and there can be no mistake about it. It should be remarked that there is a certain correction due to subjective causes which must be applied to all of these measures of the snow, by whatever method they are made. The value of this correction has not as yet been accurately determined here, but its effect will be to increase somewhat all the dimensions.

THE NORTH EASTERN FIELD.

In Figure 2 is given a map of Eratosthenes showing the various fields within and to the east of it, and indicating the names that have been assigned to them. These are designated by the letters that represent the points of the compass, and the letter C, which stands for central. They do not all develop at the same time, and indeed two of them,

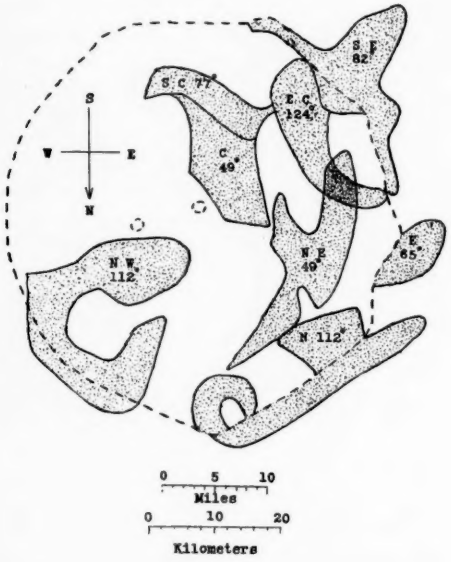


Fig. 2
MAP OF THE VARIOUS FIELDS.

the North Eastern and the East Central, overlap, the former developing early, and the latter late in the lunation. The figures given in connection with the designations indicate the colongitudes when the various fields present these particular shapes. The small rounded areas are patches of snow.

To deal fully with all the fields surrounding this crater and their constant changes would be much too large an undertaking for any single selenographer. We shall confine our investigations therefore merely to the eastern side, and study only those changes occurring within and immediately outside of the crater walls. The first field that we shall describe is that which we have designated as the North Eastern one. The eastern portion of it is first seen at colongitude 12°. By 13°.5 numerous very narrow, elongated, dark markings, possibly cracks, separated by brighter intervals appear out of the shadow. By 16° nearly the whole of the field with its numerous cracks or markings is exposed. As the shadow recedes the spaces between the cracks rapidly darken as compared with the mare to the north, at the same distance from the terminator. By 20° the field appears to have somewhat the form of a large bird, with its wings spread, flying away from the central peaks (see Figure 3). Indeed the somewhat birdlike form of this marking can even be traced in the lower right hand quadrant of Figure 2 of our first paper on this crater, which was drawn with

our 3-inch finder (POPULAR ASTRONOMY, 1919, **27**, 579). These changes all take place inside of eight hours, but as the Moon at this colongitude is only just past the first quarter, they can only be completely followed by observations made at several different lunations. The most rapid changes, other than those due to shadow, occur between 16° and 20°. In Figures 3 to 6, selected from over one hundred drawings, the crater rim and the location of the central peaks are indicated by dots.

At 20° two wide shallow craters, one to the south-west of each wing, are well shown. Each contains a minute craterlet which later emits steam and becomes brilliant. At 45° the tip of the northern wing begins to fade for a distance of about half its length, or some five miles (8 km). This fading becomes more marked at 50°, and by 60° it has quite vanished. In the mean time at 40° the eastern interior of the north-western of the two shallow craters, and the region to the west of it begin to darken, the interior of a portion of the south-eastern one having been dark from the beginning, and forming the tail of the bird (see Figure 3). By 60°, a considerable part of the floor to the west of the bird has darkened as shown in Figure 4, but this later fades again. Between 50° and 65° the southern wing extends about 5 miles, but soon after fades. Other portions of the field now shrink away as shown in Figure 5, leaving a somewhat diamond shaped body, which sometimes however assumes instead the form of a pentagon, but is quite unlike the original bird of Figure 3. Figure 5 represents its usual shape at full moon, although the outline shown in Figure 4 sometimes in part persists.

Meanwhile the outer Eastern field (Figure 2) first noticeable at 38° has darkened, advanced, and crossed the crater rim, uniting itself at about 80° to the North Eastern field, which indeed itself advanced expectantly part way to meet it (see Figures 4 and 5). This process is of some interest, but a more minute description of it must be deferred to another paper. At about 51° two dark spots in this field unite to form one. A southerly extension of the Northern field has also occurred, and this darkens further in Figure 4. Later the body of the North Eastern field begins to fade, revealing the structure of canals or runs on which in its latter days it is founded. These runs are each about a mile in width, and as they fade further, we see that the middle one, shown in Figure 5, agrees closely with the eastern interior slope of the south-eastern shallow crater mentioned above. This particular run is therefore probably due chiefly to shade.

In Figure 6 the fading can be still further traced, and a faint resemblance is now seen to the bird in Figure 3. What was the beak is now shown as a conspicuous lake or plat, with the southern wing leading away from it. The region seems to be preparing for a return to its former appearance, to be exhibited at the next lunation. Only the tip of the northern wing is now visible, but a broad run leads north-westerly from the tail, somewhat to the south of a little elliptical crater some

four miles in length, shown near the bottom of Figure 3. The altitude of the Sun as seen from the crater when Figure 6 was made was 43°, so that it is evident that these floor markings could not yet be due to shadow, as is indeed shown by their shapes. A comparison of these four drawings shows in some detail how it is that this North Eastern field darkens, spreads, and later fades and shrinks,—a process which occurs regularly, though with some variations, during every lunation.

This description typifies the changes constantly occurring in many well defined lunar fields in the course of their development, changes much more marked than any occurring upon Mars. This fact will be recognized if we consider that the apparent diameter of Mars at an average apparition is only about half that of Eratosthenes. At the time of full moon, colongitude 90°, the variation in the outline during different lunations is most marked, and some haziness of the edges is shown in spite of the dark coloration. This haziness is probably due in part to fog or mist within the crater, most noticeable at about 70°, although it may sometimes be detected as a hazy marking projected on the northwest inner wall of the crater as early as 38°. It then aligns itself more or less in the direction of Copernicus. This mist may well explain some of the variations noted.

The Central Field.

The next field that we shall describe is that which we have designated as Central. This field, unlike the North Eastern, shows no very fine detail, nor is it ever very dark, excepting when the Sun first rises on it, but it is of interest because it is large, and the changes in it therefore should be capable of being seen by northern observers. When first visible it appears as shown in Figure 3, with its eastern edge lying in a north and south direction. No marked change occurs in it before 50°, and sometimes not until nearly 70°. It then begins to narrow at its northern end, and by 60° to 80° to expand at its southern, towards the South Eastern field (Figure 2). This it soon joins by projecting towards it a run about a mile in width by five or six in length.

The run joining these two fields may be divided into three sections, the western section connecting the field with a conspicuous plat is always visible, and is clearly shown in Figure 3. The middle section joining this plat to the northern end of a dark run somewhat to the south-east of it is also shown in the same Figure. It is of the same breadth as the other, but fainter. The third and eastern section, joining the run to the South Eastern field is shown in Figure 4. It has never appeared clearly hitherto before 69°, although a broad faint shading was on one occasion drawn 10° earlier. It has been known to hold off until 86°, when it and the middle section appeared together, both growing so rapidly that we could readily watch the changes occurring in them, and their rapidly increasing width, from hour to hour. By 120° this canal or run has been recorded as reaching a width

of six miles, and five miles is by no means unusual (see Figure 5). With its appearance the whole southern portion of the Central field, that portion that we have designated in Figure 2 as South Central, begins to darken, while the northern portion begins to fade, and before long disappears.

After 115° the southern border, which has heretofore been a smooth arc, becomes more or less notched and irregular. Small bright areas, doubtless cloud, begin to border it on the south, until between 145° and 155° it gradually fades from view, and becomes indistinguishable from the regions to the north and south of it.

The changes that take place in this field, which it must be remembered has a practically level surface, since it occupies the floor of the crater, are perhaps best shown by a series of outline cuts secured on successive nights this past year. We did not sketch it on October 22, when its colongitude was 40°, but its shape on that date is very well shown in Figure 3. Figures 7, 9, and 11 show the changes that occurred on the three following nights. The vegetation did not retreat uniformly, but gradually faded out, a section at a time, beginning at the northeast, much as the wings of the bird have been seen to fade.

Figure 8, whose colongitude differs from that of Figure 7 by only 2°.7, gives an illustration of accelerated development, and closely resembles Figure 9 taken 7°.6 later. Figures 10 and 12 on the other hand show retarded development, the former resembling Figure 7, although drawn 13°.6 later. In Figure 10 the Central field was strikingly dark, 3.5, while in Figure 9 taken at nearly the same colongitude it was 4, and in part only 5. Figure 12 not only shows the Central field, which is unusual at that colongitude, but shows it exceptionally wide at the north, as compared with Figures 8 and 9. A drawing the next night, January 23, colongitude 90°.5, still showed the field, although it was then reduced to a narrow meridional band but two miles in width, or about half as wide as the South Central field.

Just as in our studies of the central snow we found by Figure 1 all the azimuths of the snow in October distinctly less than at the corresponding colongitudes in December so now we find the development of the Central field in January distinctly more retarded than it was in October. In each case the difference amounts to about twenty-four hours. In the case of the Central field the retardation may very likely be due to unusual freedom from fog on the crater floor, rather than to any actual retardation in the fading and disappearance of the vegetation itself. Thus although the dark area was recorded as invisible at colongitude 93°.6, on November 25, yet the next night, by what seems to have been a temporary clearing away of the fog, it reappeared, although rather faintly, at 106°.0. On the other hand while unusually clear of fog in February at 59°.4, yet the next night at 72°.6 Central had practically disappeared, leaving only a faint hazy trace of itself somewhat resembling in shape Figure 9, drawn 10° earlier.

THE SOUTH EASTERN AND EAST CENTRAL FIELDS.

We now come to what is one of the most interesting of all the fields of this crater, because its changes are not only very marked, but also because they occur chiefly near the time of full moon, so that they can be studied for several hours continuously. At sunrise the outer portions of the South Eastern field are in shadow, but by 40° the outer wall has lightened sufficiently to show several runs within its structure. Later it darkens, again concealing these runs. This darkening is therefore analogous to that observed earlier in the North Eastern field, on the other side of the crater wall. By 65° it is noticed that the field has crossed the crater rim, and begun the descent into the interior (see Figure 4). By 70° to 85° the narrow run from the South Central field already mentioned has advanced easterly, and connected with the advancing South Eastern field. The field meanwhile is prolonged on either side into a broad nearly straight run, which closely follows the crater rim (see Figure 4). Between 85° and 92° these runs curve rapidly inward, descending the interior slopes of the crater, and soon the field bears a fancied resemblance to a lobster or crab, with sharply curving claws (see Figure 13 drawn at colongitude 99°). In Figure 4 the northern claw has only just begun to curve, but the curving is well shown in Figure 5 after the southern one has faded. Another curved canal has now formed on the northern side behind the

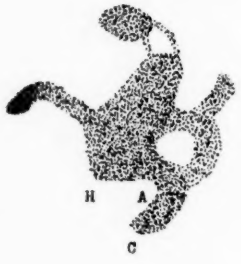


Fig. 13
1919, Oct. 9
16d, 99°4, 10, 12

front one, owing to the interior fading of the field. This is shown also in Figure 13. The advance of the dark head of the crab now progresses slowly down the crater inner wall towards the floor. This advance is not shown in these drawings.

The extent of its progress in different lunations is exceedingly variable. It usually reaches the first prominent run southeast of the three plots (Figure 3) at about 115°, but it has been recorded as reaching it at 85°, or two and a half days earlier. It might seem at first as if this

were a mistake, but it has also been recorded as well past it at 108°. In four drawings made on as many different evenings between 124° and 128° it is shown as having reached and passed the canal by different amounts up to 4 miles. It gradually fades out, and is lost in the South Central field soon afterwards. The inner crater wall in this region, which at sunrise was as bright as any other portion of the crater, or 6, has by 90°, full moon, darkened to 2, which is the maximum darkness shown anywhere at this time. By 130° the outer portion of the field begins to fade, and finally disappears before sunset.

Turning now to the remaining field located within the eastern half of the crater, and which we have designated as the East Central, we find that it differs from the others already described in several respects. The most notable one is the extremely late colongitude at which it develops. The region at all times shows a certain amount of detail. At 77°, but sometimes not until 92°, a dark spot forms on the floor of the crater, some twelve miles east of the central peak. This presently becomes joined to the South Central field by a run, which soon broadens into a pale dark band. This darkens as the lunation progresses. Runs leading northerly now appear, which broaden and darken until by 125° this field becomes a fairly conspicuous marking on the crater floor (see Figures 5 and 6). It now covers again in part the area covered earlier by the southern wing of the North Eastern field. This region therefore appears to produce two crops in each lunation. Later the field itself finally disappears in the heavy shadows which with the setting Sun come gradually creeping over the crater wall. The region where the two fields intersect is some eight square miles in area. The sunlight first strikes it at 14°. It begins to darken perceptibly at the southern wing of the bird at 45°, remains so until 70° when it fades, then darkens again at 110°, or only 9° after lunar noon, and finally disappears, the shadow covering it at about 175°. Expressing the matter otherwise, we may say that the vegetation requires two and a half days to appear, it lasts for only two days, the land rests for three days, then produces a second crop lasting for four days more, which then gradually disappears in the evening shadows. We thus have evidence of a variety in the lunar vegetation. The wings of the northern spot begin developing as soon as the sunlight strikes them, and attain their full darkness within twelve hours. Within three days half of the northern wing had faded appreciably, but the southern wing lasted for five days, and parts of the body for eleven. The East Central field on the other hand did not begin to darken for seven and a half days after the sunlight first struck it, nor get really dark for eight. The duration of the lunar vegetation therefore while varying from two to eleven days, averages about a week. In quickness of development some of it even vies with our mushrooms and toadstools. The crop has to be brief in order to ripen at all, and it is doubtful if any of it in the region we have described lasts through the lunar night.

Micrometric Measurements.

It may now be of interest to give the results of a few of our micrometric measurements. While the filar micrometer is ill adapted to planetary work, on account of the small size of the planetary disks and their rapid rotation, it is indispensible in settling certain questions relating to changes in the lunar detail. It cannot be used for very small distances to advantage, and is at its best for those between ten and forty miles. In the present work a magnification of 340 was always employed, and one position angle and four scale readings constitute a series, it being found in general that one position angle gave as small an error as two measurements, or four readings, of distance. The distances were all measured from the central craterlet. Two small craterlets one northwest and the other east of Eratosthenes were selected as primary stations. Although these craterlets are so small that they have never themselves actually been seen, yet after colongitude 20° each is surrounded by a bright hazy "glow", which soon becomes very conspicuous. These glows vary with the colongitude, and are from 6000 to 8000 feet in diameter. Their appearance is identical with that of the glow surrounding Linné, excepting for the invisibility of the craterlets and the smaller size of the glows. The distances of these primary stations from the central craterlet as measured on seven nights were 30.9 ± 0.29 and 33.3 ± 0.31 miles respectively, and their azimuth with regard to the Moon's axis at an average libration was on five nights $116°.3 \pm 0°.4$. Eleven measurements on as many different nights of the distance of a point on the crater rim at the end of the northern claw of the crab gave a distance and average deviation of 17.2 ± 0.28 miles. The mean of these three average deviations is ± 0.29 miles, equivalent to $\pm 0''.26$. In each case a correction was made for the variation in the distance of the Moon, but none for the libration, since for a crater so near the center of the disk this last was found to be unnecessary. All distances lying in a northeast and southwest direction however, if actually measured on the surface of the Moon, would, on account of the distance and direction of the crater from the center of the disk, be found to be slightly augmented.

While an average deviation of $0''.26$ may at first sight seem very large, as compared to what would be expected in the case of a double star, yet there are several independent reasons for this. The first and most important is that owing to the rapid motion of the Moon, both in right ascension and declination, it is impossible to keep the micrometer threads properly on the two objects to be compared. The second is that these objects are not points like star disks, but comparatively large surfaces, and in the case of the central peak from which the measures are made, this surface is sometimes quite irregular, and the location of the craterlet on the summit of the peak very hard to see. Our third difficulty is that our telescope is over fifty years old, and while the lens is excellent, the driving screw is particularly bad, and ill

PLATE XX

Fig. 7
1920, Oct. 23
12d, 53°0, 11

Fig. 8
1919, Nov. 4
12d, 55°7, 10

Fig. 9
1920, Oct. 24
13d, 63°3, 8

Fig. 10
1921, Jan. 21
13d, 66°6, 8

Fig. 11
1920, Oct. 25
14d, 76°8 —

Fig. 12
1921, Jan. 22
14d, 79°4, 10

DRAWINGS OF THE LUNAR CRATER ERATOSTHENES.
POPULAR ASTRONOMY, No. 287.

adapted to micrometric work. Owing to its systematic error a star swings back and forth through an arc of 7″ at each revolution of the screw, or once in every 22 seconds of time. If then in spite of these sources of error, added to the numerous very small uncorrected ones, due to the varying librations, refraction, etc., of the Moon, we can keep our average deviations down to a quarter of a second, we are quite well satisfied with the result.

Measures of the distance of the central crater from the two primary stations, carried out throughout the lunation, showed in spite of its inconspicuous character after the frost had formed around it, that what we took for the central crater was so in reality, and indicated no systematic change of position with the colongitude.

To give an example of the character of the work, and the questions that arose in connection with it, we will give an illustration of one that early occurred to us. When the claws of the crab curve inwards (Figure 13) do their tips really advance down the inner crater wall, or on the other hand does the middle section of the arms retreat down the outer wall? Since the crater rim at this colongitude was invisible, this question could not be definitely settled by the drawings. Furthermore we may ask what was the extent of the advance in miles, its rate of motion, and was there any side slip?

Three points H, C, A, shown in Figure 13, were selected for measurement, the head of the crab, the northern claw, and that portion of the arm between them which lay farthest from the central crater. In Table II the different columns give the colongitude, the date of the observation, and the azimuth and distance of each of the three points from the central crater P, with their deviations. None of the three is well defined in azimuth, but only the arm and the original claw give

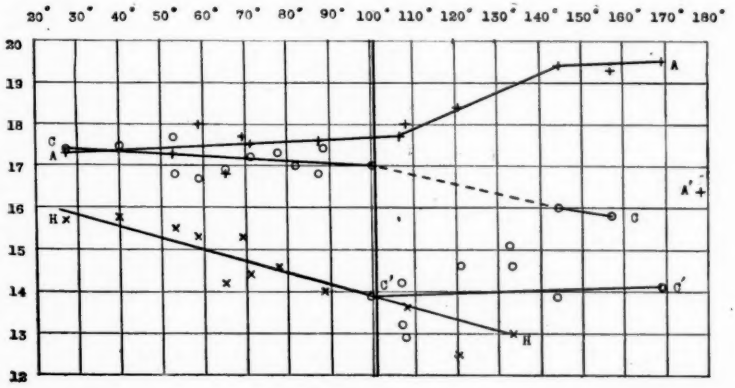


Fig. 14
GROWTH OF THE LUNAR VEGETATION.

slight indication of progressive shift, as indicated by the fifth column of the table. On the other hand there is clearly a systematic variation in the distances of all three points. This is shown in the case of the head and arm by the last column of deviations, but can be more clearly represented to the eye by the system of graphs given in Figure 14, where the abscissas give the colongitude and the ordinates the distance in miles from the central peak.

Starting with the simplest case, the head of the crab, we see by the graph H H, that as the lunation advances the front edge moves steadily towards the central peak, until it disappears or fades out, as has been already described in the text. The distance traversed is three miles, and the rate one mile in 37° of colongitude, or three days. This is only 73 feet an hour, supposing the speed absolutely uniform. Next taking the arm, AA, between the head and the claw, we see that the distance from the central peak increases slightly until 107°. It next increases sharply as the arm retreats down the outer crater wall, and then remains practically stationary for a couple of days. The maximum speed attained is one mile in two days, or half as fast again as the advance of the head. A final measurement A′ made at 178° is not of the arm itself, which had faded out, but of the edge of the crater rim, which under the late afternoon illumination appears to be located on a ridge somewhat nearer the central peaks than the ridge which appeared to form the rim when illuminated at sunrise.

The motion of the claw, CC, was at first more difficult to understand. Its distance from the central peak remained nearly constant until 100°. It then appeared to suddenly advance three miles, as at C′ C′. Further investigation showed however, that what really happened was that a fresh patch of vegetation rapidly developed at this time, just at noon, concealing the end of the claw proper, and thus giving the impression of a sudden advance. We have indicated this fact in Table II by means

TABLE II.

MICROMETRIC MEASUREMENTS.

			HEAD.			
No.	Colong.	1920	Azi.	Dev.	Miles	Dev.
1	27°3	Oct. 21	131°0	—0°5	15.7	+1.2
2	40.1	Oct. 22	131.9	+0.4	15.8	+1.3
3	53.3	Oct. 23	131.9	+0.4	15.5	+1.0
4	58.8	July 27	133.3	+1.8	15.3	+0.8
5	65.4	Oct. 24	130.5	—1.0	14.2	—0.3
6	69.7	Nov. 23	129.7	—1.8	15.3	+0.8
7	70.9	July 28	133.9	+2.4	14.4	—0.1
8	77.9	Oct. 25	128.4	—3.1	14.6	+0.1
9	88.3	Oct. 26	131.8	+0.3	14.0	—0.5
10	108.1	July 31	127.1	—4.4	13.6	—0.9
11	120.6	Aug. 1	132.7	+1.2	12.5	—2.0
12	133.8	Nov. 28	135.3	+3.8	13.0	—1.5
Mean			131.5	±1.8	14.5	±0.9

of the measures given under "Secondary Claw." The distance of this patch from the central peak remained constant until it was concealed

by the advancing shadow of the rim. In the mean time the rim reappeared at 144°, and as in the case of the arm, at a somewhat less distance than before from the central peaks.

TABLE II—Continued.

ARM.

No.	Colong.	1920		Azi.	Dev.	Miles	Dev.
1	27°.4	Oct.	21	110°.5	—3°.0	17.3	—0.6
2	52.8	Aug.	25	114.4	+0.9	17.3	—0.6
3	58.9	July	27	116.7	+3.2	18.0	+0.1
4	65.5	Oct.	24	113.5	0.0	16.8	—1.1
5	69.8	Nov.	23	113.4	—0.1	17.7	—0.2
6	71.4	July	28	116.1	+2.6	17.5	—0.4
7	87.7	Dec.	24	114.1	+0.6	17.6	—0.3
8	107.0	Sept.	28	115.0	+1.5	17.7	—0.2
9	108.2	July	31	114.4	+0.9	18.0	+0.1
10	120.7	Aug.	1	111.0	—2.5	18.4	+0.5
11	145.0	Nov.	29	114.8	+1.3	19.4	+1.5
12	156.9	Nov.	30	112.0	—1.5	19.3	+1.4
13	169.4	Dec.	1	111.6	—1.9	19.5	+1.6
14	178.2	Nov.	2	110.9	—2.6	16.4	—1.5
Mean				113.5	±1.6	17.9	±0.7

TABLE II—Continued.

ORIGINAL CLAW.

No.	Colong.	1920		Azi.	Dev.	Miles	Dev.
1	27°.4	Oct.	21	101°.8	—3°.8	17.4	+0.6
2	40.1	Oct.	22	102.5	—3.1	17.5	+0.7
3	52.9	Aug.	25	102.2	—3.4	17.7	+0.9
4	53.4	Oct.	23	103.9	—1.7	16.8	0.0
5	59.1	July	27	105.7	+0.1	16.7	—0.1
6	65.6	Oct.	24	102.4	—3.2	16.9	+0.1
7	71.4	July	28	106.8	+1.2	17.2	+0.4
8	77.9	Oct.	25	.....	.....	17.3	+0.5
9	82.1	Nov.	24	104.0	—1.6	17.0	+0.2
10	87.6	Dec.	24	108.2	+2.6	16.8	0.0
11	88.4	Oct.	26	109.5	+3.9	17.4	+0.6
12	100.1	Dec.	25	109.3	+3.7	17.0	+0.2
13	133.5	Nov.	28	108.7	+3.1	15.1	—1.7
14	144.3	Nov.	29	107.4	+1.8	16.0	—0.8
15	156.9	Nov.	30	105.6	0.0	15.8	—1.0
Mean				105.6	±2.4	16.8	±0.5

TABLE II—Continued.

SECONDARY CLAW.

No.	Colong.	1920		Azi.	Dev.	Miles	Dev.
1	100°.1	Dec.	25	109°.3	+3°.0	13.9	0.0
2	107.0	Sept.	28	104.8	—1.5	14.2	+0.3
3	107.1	Nov.	26	.....	.....	13.2	—0.7
4	108.2	July	31	107.2	+0.9	12.9	—1.0
5	120.9	Aug.	1	103.3	—3.0	14.6	+0.7
6	133.4	Nov.	28	108.7	+2.4	14.6	+0.7
7	144.2	Nov.	29	107.4	+1.1	13.9	0.0
8	169.3	Dec.	1	103.1	—3.2	14.1	+0.2
Mean				106.3	±2.2	13.9	±0.4

THE SHIFTING RUN.

In what has preceded we have purposely refrained from referring to the little system of runs and plats found in the extreme south of the crater, and shown in all four of the drawings Figures 3, 4, 5, and 6.

This was primarily because a satisfactory description of this region would have made this article too long, but secondarily because it has been our intention to mention only those changes that could under favorable conditions be detected by the great telescopes in the north. A fuller description of this region, which while only 15 miles in diameter, contains an immense amount of delicate detail, must therefore be left to a third paper. Nevertheless we find there two or three runs that at times become so conspicuous that not only the telescopes in the southwestern states already mentioned, but even those located still farther north and east, should often, especially in the summer time, be able to identify and measure them. We shall therefore now mention a phenomenon that is at the same time both interesting and curious.

Owing to the great numbers of runs crowded into this area, it has been found necessary for our own convenience to name a few of them, as well as many of the plats. The run shown in Figure 4 lying nearly parallel, and next to the southern arm of the crab, has been called Main. The one leading from the southern claw nearly at right angles to it, and passing through a large plat has been called Cross. It was early noted in our investigations that at the beginning of the lunation these two runs lay nearly at right angles to one another, but that at the time of full moon their inclination was much less. As the accuracy of our drawings increased, this deviation became so obvious, that finally when the opportunity occurred we determined to measure it.

Measures on about sixty nights have been made hitherto, but in Table III only those are included when measurements upon several nights occurred in the same lunation. These are arranged chronologically, the successive columns giving the date, the colongitude, and the azimuth of both Main and Cross.

TABLE III.

THE AZIMUTH OF MAIN AND CROSS RUNS.

Date		Colong.	Main	Cross	Date		Colong.	Main	Cross
'19 Oct.	2	14°2	50°5	.....	'20 Feb.	10	172°0	31°5	.....
	4	38.4	44.2	.....		29	39.7	35.0	.....
	6	63.8	35.9	.....	Mar.	3	74.9	19.5	.....
	7	77.0	35.4	.....			75.5	22.7	130°3
	8	88.5	32.1	131°1			78.5	14.3	129.3
	9	100.2	18.2	132.5			78.8	14.3	131.9
	10	112.5	20.2	129.2		4	91.4	10.7	131.5
	11	125.1	22.5	130.0		5	100.3	10.0	134.6
	12	137.9	24.9	126.9		7	125.2	21.6	132.4
	13	150.6	27.3	130.7	Oct.	23	52.9	33.6	130.6
Nov.	6	82.1	25.7	130.3		24	65.1	31.6	131.4
	7	93.5	12.3	129.5		25	77.5	31.3	127.2
	8	104.8	14.5	134.3			78.1	32.1	.....
	8	106.4	15.2	131.1		26	87.3	25.3	133.0
	12	157.3	21.7	128.3			87.8	23.5	133.3
'20 Feb.	2	70.5	27.4	129.5			88.8	25.4	133.7
	3	83.3	12.8	135.4			89.5	24.7	129.8
	3	83.4	12.7	.....		28	114.2	17.3	124.9
	4	94.7	12.2	131.5			114.2	18.0	.....

These results have been plotted in Figure 15, where the abscissas give the colongitudes, and the ordinates the azimuths of the two runs. The dark lines join those observations that were made during the same

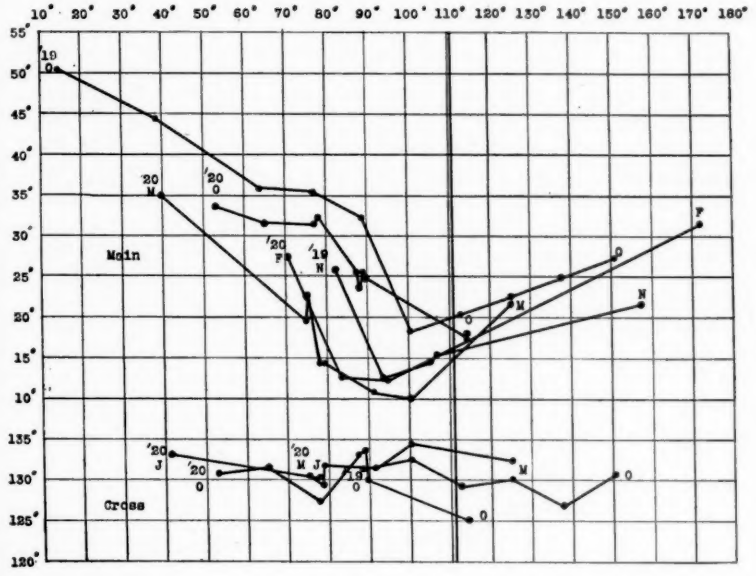


Fig. 15
POSITION ANGLES OF MAIN AND CROSS RUNS.

lunation. It will be seen at once that while the azimuth of Cross varies little if any, that of Main shifts markedly. Until 70° it diminishes at a rate of about 1° in azimuth for 4° in colongiude, or at a rate of 3° per day. Shortly after 70° for twenty-four hours, the rate is 15° per day. The colongitude at which this sudden change occurs varies in different lunations, but appears always to lie between 70° and 90°. Later the azimuth increases at a rate of from 2° to 3° per day.

It will be noted that the colongitude is obtained with absolute precision, since it depends merely on the hour at which the observation was made, and varies at the rate of 1° in two hours. Taking two extreme cases we find the azimuth of Main in October 1919 at colongitude 90° to be 31°, in March 1920 it was only 11°,—a difference which, considering the results of preceding nights, could not possibly be due to an error of measurement. In October 1920, at colongitude 90°, we find four measurements made on the same night. Their variations show the sort of accidental deviations we should expect to find. Similar measures of Cross made during different lunations indicate what accidental deviations might occur in measures made on different nights.

In order to determine which end of Main shifted, a series of micrometric measures of the distance of the two ends from the central peak was next made. This indicates that both ends gradually recede up the inner slope of the crater as the lunation progresses. Incidentally it may be mentioned that this is the opposite direction to that in which a shadow would move. The western end recedes first and then stops, and later the eastern one begins to move, causing the shift in azimuth. It further appears that changes in azimuth can be measured with greater accuracy than those in distance. As a provisional result it seems that the eastern end of the run recedes three miles in five days, or at the average rate of 132 feet per hour. The run is six miles in length by one in width. The ultimate mean recession of the whole run is over a mile, or more than its width, and it is suspected, although not as yet proved, that the recession of the eastern end is broken by occasional advances. Any such irregularities, if they could be proved, would be of great interest.

It thus appears that the runs on the Moon like the canals on Mars shift their positions over the surface. In both cases a surface discoloration has changed its place. This cannot be due to mineral or inorganic forces. Life therefore exists on both these planets. The shift in azimuth of Main when at maximum speed is so rapid that we can even detect the change in the course of a long evening's observation. Thus on March 3, 1920, by Table III, and also by Figure 15, we see that the mean of the first two azimuths is 21°.1, the mean of the last two 14°.3 The azimuth has shifted 6°.8 in a difference of colongitude of 3°.4, or in seven hours. We are thus actually able to watch the effects of life as it slowly moves across the surface of the Moon.

Summary of Results.

The following table gives the more marked changes that have hitherto been recorded in this crater, together with the colongitudes at which they may be expected to appear.

TABLE IV.

No.	Colong.	Effect.
1	12°	The North Eastern field first becomes partially visible.
2	14.6	The summit of the central peak first shows.
3	20	The middle section of the run joining the South Central and South Eastern fields sometimes appears.
4	38	Fog begins to form within the crater, but is most marked at about 70°.
5	40	The runs appear in the outer portion of the South Eastern field.
6	40	The eastern side of the north-western floor crater darkens.
7	45	The northern portion of the North Eastern field begins to fade, and the southern portion to extend.
8	51	The two dark spots in the Eastern field unite.
9	60	The Central field begins to narrow at the northern end.
10	60	The Northern field crosses the crater rim and begins to extend towards the south.
11	65	The South Eastern field crosses the rim.

No.	Colong.	Effect.
12	70°	The eastern section of the run joining the South Central and South Eastern fields sometimes appears. The South Central field darkens.
13	70	The southern portion of the North Eastern field begins to fade.
14	80	The East Central field darkens, at 125° is conspicuous, and at 175° is lost in the shadows.
15	80	The Eastern field joins the North Eastern, which soon begins to shrink.
16	85	The two arms of the South Eastern field begin to curve inward.
17	115	The South Central field becomes notched at the south and fades out at 150°.
18	115	What has been called the "head" of the South Eastern field reaches Main run. It was once recorded as doing so at 85°.
19	130	The outer portion of the South Eastern field begins to fade.
20	130	The North Eastern field also fades.

To these should be added the gradual changes in azimuth and size of the central snows, the varying distances from the center to certain areas of vegetation located near the rim of the crater, and also the changes in azimuth and distance from the central peak of the run which we have designated as Main.

Finally in closing this article we may say that while we do not yet clearly understand the nature of the life that is here described, and laid before our eyes upon the Moon, yet that very fact only adds to the interest that it inspires in our minds. We find there a living world, lying at our very doors, where life in some respects resembles that on Mars, but is entirely unlike anything on our own planet,—a world which the astronomical profession in general, for the past fifty years, has utterly and systematically neglected and ignored.

Mandeville, Jamaica, B. W. I.,
April 12, 1921.

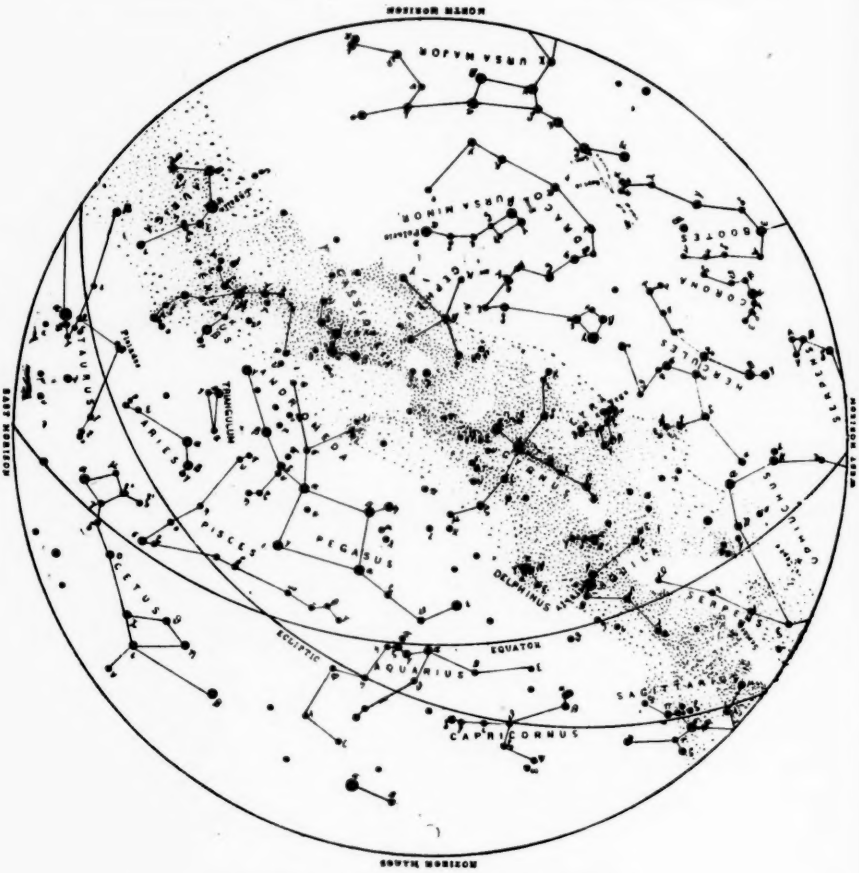
PLANET NOTES FOR SEPTEMBER AND OCTOBER.

(All times used are Central Standard unless otherwise noted.)

The *sun* will enter the sign of Libra September 23 at $8^h\ 20^m$ A. M. marking the beginning of autumn.

A total eclipse of the sun will occur October 1. The path of totality begins in the Pacific Ocean west of Cape Horn and ends very near the south pole. The path as shown on the map of the American Ephemeris is about 260 miles wide but this exceptional width will be of no value as it crosses no inhabited regions.

A partial eclipse of the *moon* will take place October 16. The middle of the eclipse will occur at $4^h\ 54^m$ P. M. and will thus be invisible over most of North America but before the moon leaves the umbra at $6^h\ 34^m$ P. M. it will be above the horizon for most of the western hemisphere.



THE CONSTELLATIONS AT 9:00 P. M. OCTOBER 1.

The moon's phases will occur as follows:

New Moon	Sept.	1	at 9:33.0 P. M.
First Quarter		8	" 9:29.5 P. M.
Full Moon		17	" 1:20.0 A. M.
Last Quarter		24	" 3:17.7 P. M.
New Moon	Oct.	1	" 6:26.4 A. M.
First Quarter		8	" 2:11.8 P. M.
Full Moon		16	" 4:59.6 P. M.
Last Quarter		23	"10:31.5 P. M.
New Moon		30	" 5:38.8 P. M.

Mercury will be at eastern elongation October 7. Its distance from the sun will be over 25° so that it should be possible to see it low in the western sky after sunset. The planet will be at inferior conjunction on the 31st of October.

Venus continues as morning star during this time. The planet will be at

Neptune, having been in conjunction with the sun on August 6, will not be morning of October 22 and within 31′ of Jupiter three days later.

Mars will slowly emerge from the rays of the sun, being a little over an hour from the latter September 1 and two and one-half hours from it by the end of October.

Jupiter and *Saturn* will be in conjunction with the sun on September 22 and 21 respectively. Both planets will therefore be too near the sun for good observation during the period.

Uranus being just past opposition will be favorably located for observation. The chart published in the January number may be of help in locating the planet.

Neptune, having been in conjunction with the sun on August 6, will not be in good position for observation until later in the year.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1921	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle E from N	EMERSION. Washington M.T.	EMERSION. Angle E from N	Duration
			h m	°	h m	°	h m
Sept. 8	29 Ophiuchi	6.4	9 43	32	10 24	321	0 40
16	13 Piscium	6.4	10 6	38	11 26	266	1 20
18	ζ Piscium	5.6	15 52	19	16 44	299	0 51
21	30 B Tauri	6.4	9 22	92	10 17	237	0 55
24	26 Gemin.	5.2	16 28	68	17 41	300	1 13
25	68 Gemin.	5.2	12 45	108	13 38	258	0 53
26	84 B Cancri	6.4′	13 25	73	14 13	302	0 48
Oct. 7	*Y* Sagitt. (var.)	5.4	4 54	52	6 12	297	1 18
11	c^2 Capric.	6.3	11 46	43	12 52	270	1 6
15	147 B Piscium	5.9	8 9	11	8 54	298	0 45
15	171 B Piscium	6.3	16 5	38	16 57	288	0 52
19	64 Tauri	4.9	12 15	19	12 56	315	0 42
20	115 Tauri	5.3	15 36	143	16 27	216	0 51
21	124 H^3 Orionis	5.7	9 48	57	10 37	296	0 49
21	292 B Orionis	6.5	12 56	108	14 7	249	1 11
22	λ Gemin.	3.6	12 9	83	13 13	282	1 3

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1921							
					Sept.				Oct.			
	h m	° ′		d h	d h		d h		d h		d h	
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			29	21				
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	11	17	27	1	4	17	20	2
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	8	10	23	7	8	4	23	0
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	9	8	24	7	9	6	24	5
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	2	15	20	23	9	8	27	16
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	7	4	21	10	5	17	20	0
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	5	21	19	14	3	8	23	22
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	4	6	18	14	10	2	24	11
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	8	22	26	12	5	7	22	20
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	3	21	19	18	5	16	21	13
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	7	3			9	10		
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	2	7	19	12	6	17	23	21
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	5	16	19	7	9	16	30	1
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	4	19	20	14	6	10	22	5
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8	3	24	17	11	8	27	23
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	6	16	22	11	8	6	24	1
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	2	1	28	11	11	16	24	20
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	6	20	25	17	5	4	24	1
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	7	15	20	1	2	11	27	7
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	4	12	17	19	7	19	21	3
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	9	6	25	14	11	23	28	8
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	8	16	26	18	14	19	26	20
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	6	3	23	11	10	19	28	3
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	4	19	25	15	6	0	26	20
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	8	22	24	23	10	23	27	1
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	3	4	20	9	7	13	24	18
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	3	15	20	10	7	5	24	0
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	7	16	24	2	10	11	26	21
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	8	10	23	16	8	22	24	4
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	5	19	30	5	12	10	24	15
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	9	4	23	12	7	20	22	4
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	8	16	22	7	5	22	19	13
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	2	7	20	21	9	12	28	2
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	4	7	24	3	7	8	27	4
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	6	15	23	10	10	5	27	0
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	10	19	23	15	6	12	19	9
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	7	20	22	9	6	22	21	11
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	4	21	21	3	7	9	23	15
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	5	11	24	10	3	22	22	21
RX Hydræ	9 00.8	— 7 52	9.1—10.5	2 6.8	7	21	21	13	5	6	25	19
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	3	13	21	8	9	4	21	0
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	8	18	25	14	12	11	29	8
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	4	16	30	14	13	14	26	14
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	7	13	20	18	3	23	30	8
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	14	0	22	19	10	10	28	0
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	4	8	18	23	3	15	18	7
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3	0	30	4	13	17	27	7
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	5	9	18	12	1	15	27	22
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	2	21	22	2	11	6	30	11
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	3	6	17	16	2	1	16	11
133926 Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	9	2	23	14	8	2	22	13

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1921							
								Sept.				Oct.			
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
δ Libræ	14	55.6	—	8 07	4.8— 6.2	2	07.9	8	4	19	20	1	11	24	17
U Coronæ	15	14.1	+32	01	7.6— 8.7	3	10.9	8	6	22	2	5	21	19	17
TW Draconis	15	32.4	+64	14	7.3— 8.9	2	19.3	12	2	28	2	12	3	26	4
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	5	21	21	4	6	12	21	20
SW Ophiuchi	16	11.1	—	6 44	9.2—10.0	2	10.7	5	2	29	12	11	18	24	0
SX Ophiuchi		12.6	—	6 25	10.5—11.2	2	01.5	3	13	24	4	14	19	25	2
R Aræ		31.1	—56	48	6.8— 7.9	4	10.2	8	20	22	2	5	9	18	15
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	14	13			5	7	26	1
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	1	22	24	14	5	22	28	14
U Ophiuchi		11.5	+	1 19	6.0— 6.7	0	20.1	1	15	18	10	5	5	21	23
μ Herculis		13.6	+33	12	4.6— 5.4	2	01.2	6	17	19	0	7	11	25	22
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	5	16	24	5	12	18	25	3
RV Ophiuchi		29.8	+	7 19	9. —12	3	16.5	9	21	24	15	9	9	31	12
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	4	11	20	20	7	4	23	13
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	9	16	24	18	9	19	24	21
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	11	16	27	4	12	16	28	3
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	11	11	27	11	13	10	29	9
WX Sagittarii		53.6	—17	24	9.2—10.8	2	03.1	4	12	21	13	8	14	25	14
WY Sagittarii	17	54.9	—23	1	9.5—10.6	4	16.0	3	1	21	17	10	9	29	1
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	9	19	30	11	10	19	21	3
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	8	18	23	6	7	18	22	6
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	6	10	20	5	10	23	24	18
RZ Scuti		21.1	—	9 15	7.4— 8.3	15	03.2	5	4	20	7	5	11	20	14
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	7	5	21	13	5	21	20	4
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	7	2	21	8	12	16	26	21
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	8	7	24	22	11	13	28	4
RR Draconis		40.8	+62	34	9.3—13	2	19.9	4	23	21	23	8	22	25	22
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	5	5	25	3	8	10	28	8
β Lyræ		46.4	+33	15	3.4— 4.1	12	21.8	2	3	27	22	10	20	23	18
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	8	22	24	5	9	12	24	18
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	2	20	25	13	10	16	25	20
RV Lyræ		12.5	+32	15	11. —12.8	3	14.4	9	14	24	0	8	9	22	19
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	10	9	28	7	7	6	25	3
U Sagittæ		14.4	+19	26	6.5— 9.0	3	09.1	5	6	18	19	9	2	22	14
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	2	3	24	5	8	23	23	16
TT Lyræ		24.3	+41	30	9.4—11.6	5	05.8	9	6	24	23	5	11	21	4
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	5	8	24	21	7	23	27	12
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	12	14	24	15	12	15	24	16
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	10	6	23	12	13	10	26	16
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	7	14	25	21	5	1	23	7
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	8	3	25	0	11	20	28	17
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	7	17	21	7	11	16	25	5
UW Cygni		19.6	+42	55	10.5—13	3	10.8	7	19	21	15	5	10	19	5
V Vulpec.		32.3	+26	15	8.2— 9.8	37	19.0			16	2			23	21
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	4	1	23	6	2	21	22	2
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	10	16	29	2	8	6	26	16
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	6	1	21	1	6	1	28	12
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	7	19	22	23	8	4	23	9
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	10	21	20	23	11	4	21	6
VVCygni	21	02.3	+45	23	12.1—13.8	1	11.4	2	2	24	5	9	0	23	18
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	11	6	30	16	10	8	29	17
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	9	20	25	13	11	8	27	1
RT Lacertæ	21	57.4	+43	24	9.1—10.5	5	01.7	11	20	22	0	2	3	22	10
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3	10	16			11	23		
RW Lacertæ	22	40.6	+49	08	10.2—11.2	5	04.4	7	3	22	16	8	5	23	18
8.1914 Pegasi		51.7	+32	41	10.0—10.6	5	06.4	9	6	23	1	9	20	25	16
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.4	6	6	22	21	9	11	26	1
Y Piscium		29.3	+	7 22	9.0—12.0	3	18.3	5	10	20	12	5	13	20	15
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	7	21	24	9	10	20	27	8

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900		Decl. 1900		Magnitude		Approx. Period		Greenwich mean times of maxima in 1921							
									Sept.				Oct.			
	h	m	°	′			d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6—	9.2	36	13.7			25	14				
SY Cassiop.	0	09.8	+57	52	9.3—	9.9	4	1.7	8	23	25	5	11	12	27	19
RR Ceti	1	27.0	+ 0	50	8.3—	9.0	0	13.3	2	17	17	4	3	16	26	22
RW Cassiop.	1	30.7	+57	15	8.9—	11.0	14	19.2	5	3	19	22	4	17	19	12
V Arietis	2	09.6	+11	46	8.3—	9.0	0	23.8	8	17	24	14	10	11	26	8
SU Cassiop.	2	43.0	+68	28	6.5—	7.0	1	22.8	10	7	25	21	3	16	19	7
TU Persei	3	01.8	+52	49	11.4—	12.2	0	14.6	9	2	23	16	8	6	22	19
RW Camelop.	3	46.2	+58	21	8.2—	9.4	16	00.0	12		28		14		30	
SX Persei	4	10.2	+41	27	10.4—	11.2	4	07.0	9	2	26	6	4	20	21	0
SV Persei		42.8	+42	07	8.8—	9.6	11	03.1	6	2	29	8	9	11	31	17
RX Aurigæ	4	54.5	+39	49	7.2—	8.1	11	15.0	9	19	21	11	3	2	26	7
SX Aurigæ	5	04.6	+42	02	8.0—	8.7	1	12.8	6	1	21	9	5	16	19	0
SY Aurigæ		05.5	+42	41	8.4—	9.5	10	03.3	10	11	29	17	9	21	30	3
Y Aurigae		21.5	+42	21	8.6—	9.6	3	20.6	5	19	21	6	6	16	22	3
RZ Gemin.	5	56.6	+22	15	9.1—	10.0	5	12.7	8	11	19	12	11	15	22	16
RS Orionis	6	16.5	+14	44	8.2—	8.9	7	13.6	2	15	17	18	10	11	25	14
T Monoc.		19.8	+ 7	08	5.7—	6.8	27	00.3			17	16	14	16		
RT Aurigæ		23.0	+30	33	5.1—	6.0	3	17.5	11	12	26	10	3	21	18	18
RZ Camelop.		23.7	+67	06	11.0—	13.0	0	11.5	7	21	22	7	13	22	28	8
W Gemin.		29.2	+15	24	6.7—	7.5	7	22.0	6	17	22	13	8	9	24	5
ζ Gemin.	6	58.2	+20	43	3.7—	4.3	10	03.7	3	21	24	5	4	8	24	16
RU Camelop.	7	10.9	+69	51	8.5—	9.8	22	06.5	9	13	31	19			24	2
RR Gemin.	7	15.2	+31	04	10.0—	11.5	0	09.5	9	12	24	9	2	8	18	6
V Carinæ	8	26.7	−59	47	7.4—	8.1	6	16.7	7	9	20	19	4	4	24	6
T Velorum	8	34.4	−47	01	7.6—	8.5	4	15.3	4	6	22	20	11	9	29	22
V Velorum	9	19.2	−55	32	7.5—	8.2	4	08.9	8	17	26	5	4	23	22	10
Z Leonis	9	46.4	+27	22	7.9—	9.6	59	00.0			25					
RR Leonis	10	02.1	+24	29	9.1—	10.1	0	10.9	7	8	20	22	4	11	24	20
SU Draconis	11	32.2	+67	53	8.9—	9.6	0	15.8	6	19	20	0	3	5	23	1
S Muscæ	12	07.4	−69	36	6.4—	7.3	9	15.8	5	6	24	14	4	6	23	13
SW Draconis		12.8	+70	04	8.8—	9.6	0	13.7	2	13	18	12	4	11	20	9
T Crucis		15.9	−61	44	6.8—	7.6	6	17.6	5	16	19	3	9	8	22	19
R Crucis		18.1	−61	04	6.8—	7.9	5	19.8	4	13	22	0	3	16	21	3
S Crucis	12	48.4	−57	53	6.5—	7.6	4	16.6	5	18	19	20	3	22	22	16
W Virginis	13	20.9	− 2	52	8.7—	10.4	17	06.5			17	0	4	6	21	13
SS Hydræ		25.0	−23	08	7.4—	8.1	8	04.8	5	10	21	19	8	5	24	14
RV Urs. Maj.	13	29.4	+54	31	9.2—	9.9	0	11.2	4	13	25	14	9	15	23	16
ST Virginis	14	22.5	− 0	27	10.3—	11.4	0	09.9	5	16	22	2	8	12	24	22
V Centauri		25.4	−56	27	6.4—	7.8	5	11.9	9	7	20	7	6	18	23	6
RS Bootis		29.3	+32	11	8.9—	10.0	0	09.1	3	12	26	3	11	5	26	7
RU Bootis	14	41.5	+23	44	12.8—	14.3	0	11.9	10	21	25	17	10	12	25	8
R Triang. Austr.	15	10.8	−66	08	6.7—	7.4	3	09.3	6	1	19	15	9	23	23	12
S Triang. Austr.	15	52.2	−63	29	6.4—	7.4	6	07.8	6	22	19	14	8	13	27	12
S Normæ	16	10.6	−57	39	6.6—	7.6	9	18.1	5	17	25	6	5	0	24	12
RW Draconis		33.7	+58	03	9.6—	10.8	0	10.6	11	0	28	17	7	14	25	7
RV Scorpii	16	51.8	−33	27	6.7—	7.4	6	01.5	4	5	22	10	4	13	22	17
X Sagittarii	17	41.3	−27	48	4.4—	5.0	7	00.3	3	7	24	8	8	8	22	9
Y Ophiuchi		47.3	− 6	07	6.1—	6.5	17	02.9	5	16	22	19	9	22	27	1
W Sagittarii	17	58.6	−29	35	4.3—	5.1	7	14.3	4	4	18	9	4	13	19	18
Y Sagittarii	18	15.5	−18	54	5.4—	6.2	5	18.6	9	5	20	18	7	2	24	10
U Sagittarii		26.0	−19	12	6.5—	7.3	6	17.9	8	1	21	12	11	18	25	6
Y Scuti		32.6	− 8	27	8.7—	9.2	10	08.3	6	8	27	1	7	9	28	2
Y Lyræ		34.2	+43	52	11.3—	12.3	0	12.1	5	17	23	29	5	21	23	23
RZ Lyræ	18	39.9	+32	42	9.9—	11.2	0	12.3	2	3	20	13	8	23	21	5

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1921							
					Sept.				Oct.			
	h m	° ′		d h	d h		d h		d h		d h	
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	6	6	24	2	11	22	23	20
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	6	0	24	5	3	7	21	11
U Aquilæ	19 24.0	− 7 15	6.2— 6.9	7 00.6	6	19	20	20	11	22	25	23
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	6	17	20	17	11	17	25	17
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	5	9	22	8	7	7	23	6
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	7	1	20	10	7	20	23	5
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	3	13	17	21	2	6	23	18
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	5	15	22	10	9	4	25	22
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	3	8	22	7	11	6	30	5
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	5	13	21	22	8	7	24	17
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	5	6	23	0	6	7	24	1
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	5	10	18	21	2	8	22	12
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	7	3	20	13	10	16	24	3
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	15	1	29	19	14	12	29	6
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	8	7	24	0	9	17	25	10
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	5	8	19	3	9	19	23	13
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4	11	23	22	8	12	23	2
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	7	19	22	18	2	17	17	16
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	11	11	22	5	8	7	24	9
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	3	6	25	0	5	21	27	15
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	7	7	20	3	9	10	22	6
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	7	19	22	18	7	17	22	16
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	8	0	18	21	5	5	21	13
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	6	3	22	11	8	18	25	2
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	10	2	22	17	11	14	24	4
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	7	10	18	13	1	17	26	0
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	8	14	22	13	6	12	20	11

New Variable Stars.—Harvard College Observatory Circular No. 225 contains a list of fifty-one new variable stars discovered at the Harvard Observatory during the past two years. These are in addition to eight novae and several other variables which have already been announced. They have been discovered on photographic plates, and are all too faint even when at maximum to be seen with the naked eye. They are mostly in the Milky Way.

Monthly Report of the American Association of Variable Star Observers, April 20 to June 20, 1921.

R Coronae Borealis, 154428, has again decreased in light, reaching a minimum of 7.5 on June 14. RY Sagittarii, *191033*, has been fainter than normal during June. It remained about the eighth magnitude.

Mr. Ed de Perrot has left Switzerland for Cracow, Poland. Mr. Howard Eaton has gone to England to study.

Included in this report are lists from three new observers, Mr. W. F. H. Waterfield of Nakusp, B. C., Mr. Raymond Williams of Fayetteville, N. Y., and Mr. Kaname Nakamura of the Kyoto University Observatory. The following is a list of all who contributed to this double report: Messrs. Bancroft "Ba," Barns "Bs," Bouton "B," Carr "Ca," Chandler "Cd," Chandra "Ch," Clement "Cl," Miss Clough "Cg," Delmhorst "De," Dunham "Du," Ginori "Gi,"

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921.

Star	April 0 = 2422780 J.D.	Est.Obs.	May 0 = 2422810 J.D.	Est.Obs.	June 0 = 2422841 J.D.	Est.Obs.	J.D.	Est.Obs.
001046 X ANDROMEDAE—	2840.8	<13.3 Wf,	2849.8	<13.0 Wf,	2850.8	<12.0 M.		
001755 T CASSIOPEIAE—	2762.5	7.6 Ba,	2783.3	7.7 Gi,	2783.3	7.8 L,	2815.8	8.0 Pt,
	2816.6	7.9 L,	2840.5	8.1 L,	2850.0	8.8 M.		
003179 Y CEPHEI—	2762.5	<13.0 Ba.						
004047 U CASSIOPEIAE—	2762.5	10.2 Ba,	2840.8	<12.8 Wf,	2850.8	<12.6 Wf.		
004633 RR ANDROMEDAE—	2843.9	<12.6 Wf,	2850.8	<12.6 Wf.				
004746a RV CASSIOPEIAE—	2782.3	10.3 L,	2815.8	11.0 Pt,	2816.6	11.1 L,	2840.5	11.9 L.
004958 W CASSIOPEIAE—	2762.5	9.3 Ba,	2783.4	9.4 Gi	2808.7	<9.5 Cg,	2815.8	10.3 Pt,
	2819.7	<9.5 Cg,	2836.6	<9.5 Cg,	2852.8	11.2 Pt,	2853.6	<9.5 Cg.
011272 S CASSIOPEIAE—	2751.5	<12.6 Rk,	2752.3	<12.6 Rk,	2762.5	<13.3 Ba,	2823.8	<13.6 Wf,
	2843.8	13.3 Wf.						
012350 RZ PERSEI—	2762.5	10.2 Ba.						
013238 RU ANDROMEDAE—	2759.1	<11.5 Ch,	2843.9	11.6 Wf.				
013338 Y ANDROMEDAE—	2759.1	8.5 Ch.						
014958 X CASSIOPEIAE—	2762.5	10.2 Ba,	2806.6	11.6 Y,	2815.8	12.1 Pt.		
015354 U PERSEI—	2762.5	7.9 Ba,	2815.8	8.7 Pt,	2854.8	9.1 Pt.		
021024 R ARIETIS—	2782.3	9.4 Gi,	2782.3	9.5 L.				
021143a W ANDROMEDAE—	2762.5	<13.0 Ba,	2780.3	13.2 Gi,	2840.0	12.3 Wf.		
021258 T PERSEI—	2785.0	9.1 Jk.						
021381 Z CEPHEI—	2762.5	<13.5 Ba.						
021558 S PERSEI—	2762.5	9.4 Ba,	2784.9	9.9 Jk.				
022150 RR PERSEI—	2762.5	11.0 Ba,	2805.6	13.0 Y.				
023080 RR CEPHEI—	2753.4	13.1 L,	2762.5	<13.0 Ba,	2794.4	12.7 L,	2807.4	11.6 L,
	2816.4	10.2 L,	2823.8	10.2 Wf,	2840.8	10.1 Wf.		
023133 R TRIANGULI—	2762.5	7.5 Ba,	2854.8	7.1 Pt.				
024356 W PERSEI—	2762.5	9.5 Ba,	2807.6	10.2 Pt,	2841.8	10.5 Pt.		
030514 U ARIETIS—	2782.3	8.1 Gi.						
031401 X CETI—	2783.3	10.0 L.						
032043 Y PERSEI—	2762.5	8.4 Ba,	2804.6	9.3 Gd,	2807.6	8.7 Pt,	2854.8	9.9 Pt.
032335 R PERSEI—	2780.4	<13.6 Gi.						
033362 U CAMELOPARDALIS—	2762.5	7.2 Ba.						
041619 T TAURI—	2762.5	9.5 Ba.						

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
042215 W TAURI—												
	2762.6	9.8	Ba,	2807.6	10.0	Pt.						
042209 R TAURI—												
	2762.6	12.5	Ba.									
042309 S TAURI—												
	2762.6<	12.5	Ba.									
043065 T CAMELOPARDALIS—												
	2762.6	9.6	Ba,	2782.4	9.5	L,	2794.4	9.2	L,	2808.6	9.0	Pi,
	2816.4	8.8	L,	2822.7	8.6	Bs,	2835.4	8.5	L.	2851.7	7.8	Bs.
043274 X CAMELOPARDALIS—												
	2753.6	11.6	Ba,	2762.6	10.9	Ba,	2785.0	8.7	Jk,	2805.6	8.5	Y,
	2807.6	8.0	Pt.	2808.5	8.2	O.	2808.6	8.8	Pi.	2822.4	9.0	Rk,
	2836.6	8.5	Y,	2837.7	11.0	Pt,	2850.4	8.9	Rk,	2857.4	8.5	Rk.
043208 RX TAURI—												
	2762.6<	12.0	Ba.									
044617 V TAURI—												
	2762.6	11.1	Ba.									
045307 R ORIONIS—												
	2762.6	12.3	Ba,	2780.4	11.6	Gi.						
045514 R LEPORIS—												
	2750.3	7.5	Rk,	2751.3	7.5	Rk,	2752.3	8.9	L,	2774.1	9.7	Ch,
	2783.1	9.3	Ch.									
050003 V ORIONIS—												
	2796.6	9.2	B.									
050953 R AURIGAE—												
	2753.5	12.6	Ba,	2807.6	11.3	Pt,	2807.6	11.4	Ya,	2809.7	11.0	Lv,
	2818.6	11.1	Lc,	2819.6	10.0	Gd,	2840.6	10.3	Pt.			
052034 S AURIGAE—												
	2753.5	8.5	Ba,	2781.3	9.2	Pe,	2783.3	8.2	L,	2788.3	9.0	Pe,
	2794.3	8.4	L,	2796.6	8.7	B,	2807.3	9.0	Pe,	2807.6	8.6	Ya,
	2816.3	8.4	L.									
052036 W AURIGAE—												
	2753.5<	13.0	Ba,	2780.4	13.4	Gi.	2783.3<	11.0	L,	2804.3	12.9	Gi,
	2816.3	12.4	L,	2817.3	12.5	Gi.						
052404 S ORIONIS—												
	2753.5	11.2	Ba,	2796.5	11.1	B.						
053068 S CAMELOPARDALIS—												
	2753.5	8.0	Ba,	2807.6	8.6	Pt,	2808.6	9.0	Pi,	2837.7	9.5	Pt.
053005a T ORIONIS—												
	2753.5	10.9	Ba,	2782.3	10.0	L,	2792.3	10.1	L,	2796.6	10.1	B,
	2807.6	10.6	Pt.									
053326 RR TAURI—												
	2782.4	12.5	Ja.									
053531 U AURIGAE—												
	2753.6	9.7	Ba,	2799.5	9.2	B,	2806.6	10.0	Y,	2807.6	9.4	Pt,
	2807.6	9.8	Ya.									
054319 SU TAURI—												
	2753.6	9.5	Ba,	2758.3	9.3	Rk,	2761.2	9.8	Ch,	2762.5	9.5	Ba,
	2775.1	9.7	Ch,	2780.0	9.5	Jk,	2780.0	9.6	Ym,	2781.4	9.6	L,
	2783.1	9.5	Ch,	2784.0	9.5	Ym,	2784.3	9.4	L,	2785.0	9.4	Jk,
	2785.4	9.7	Pe,	2792.3	9.4	L,	2799.6	9.4	B,	2800.6	9.5	Du,
	2805.0	9.7	Ym,	2806.5	9.8	Cl,	2807.6	9.4	Pt,	2810.5	9.5	B,
	2811.6	9.5	Pt,	2812.0	9.8	Ym,	2814.3	9.6	L,	2815.6	9.5	Pt,
	2816.3	9.5	L.									
054974 V CAMELOPARDALIS—												
	2753.6<	13.5	Ba,	2762.6<	13.5	Ba,	2780.5<	14.0	Gi,	2797.6<	12.2	De,
	2799.6<	12.8	B,	2805.6<	13.0	Y,	2807.4<	14.0	Gi,	2808.6<	11.3	Pi,
	2809.6<	13.5	B,	2836.6<	12.8	Y.						
054920 U ORIONIS—												
	2675.0	9.9	Nk,	2690.0	10.6	Nk,	2702.2	11.0	Nk,	2715.0	11.2	Nk,
	2729.0	11.4	Nk,	2753.6	11.5	Ba,	2761.2	12.2	Ch,	2775.1	11.3	Ch,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
054920 U ORIONIS—												
	2783.1	11.4	Ch,	2783.3	11.9	Pe,	2784.0	11.3	Ym,	2785.4	11.5	Pe,
	2789.0	10.8	Ym,	2798.6	9.3	B,	2805.0	10.5	Ym,	2805.7	<9.9	Cg,
	2807.1	10.1	Ch,	2807.6	9.2	Pt,	2809.6	10.0	Lv,	2812.0	9.7	Ym.
054920b UV ORIONIS—												
	2809.7	10.7	Lv.									
055353 Z AURIGAE—												
	2753.6	10.4	Ba,	2801.6	9.5	Y,	2807.6	10.1	Pt,	2810.6	9.6	B,
	2817.6	9.5	B,	2822.8	9.8	Wf,	2823.7	9.9	Wf,	2840.6	10.3	Pt,
	2842.6	10.3	Y.									
060450 X AURIGAE—												
	2753.6	11.3	Ba,	2798.6	8.7	B,	2802.5	8.8	Ro,	2806.6	8.7	De,
	2807.6	8.9	Pt,	2809.5	8.6	Ro,	2817.5	8.5	Ro,	2840.6	9.4	Pt.
060547 SS AURIGAE—												
	2753.5	<13.8	Ba,	2756.6	<13.5	Ba,	2761.2	<11.8	Ch,	2762.6	<13.5	Ba,
	2780.0	<13.9	Ym,	2780.5	<13.8	Gi,	2781.0	<13.3	Ym,	2781.2	<14.8	Ch,
	2781.4	<14.5	L,	2782.3	<13.9	Gi,	2782.3	<14.5	L,	2782.4	<12.6	Pe,
	2782.4	<13.3	Ja,	2783.3	<12.6	Pe,	2783.3	<14.0	L,	2783.4	<13.3	Ja,
	2783.4	<13.9	Gi,	2784.0	<13.3	Ym,	2784.3	<14.0	L,	2784.4	<13.9	Gi,
	2785.4	<13.3	Js,	2786.4	<13.3	Ja,	2788.0	<13.3	Ym,	2791.3	<13.9	Gi,
	2791.4	<14.0	L,	2792.3	<14.0	L,	2792.4	<13.8	Gi,	2793.3	<13.8	Gi,
	2794.3	<13.3	L,	2799.3	<13.3	Gi,	2799.4	<12.9	L,	2800.6	<10.5	Pw,
	2801.4	<13.0	L,	2802.3	<13.3	Gi,	2802.4	<12.4	L,	2804.3	13.7	Gi,
	2804.5	<10.8	O,	2805.0	11.4	Ym,	2805.3	10.8	Gi,	2805.5	11.0	O,
	2805.6	10.9	Cl.	2805.6	11.0	Y,	2806.4	10.7	Ja,	2806.4	10.7	Pe,
	2806.6	10.6	Cl,	2806.6	10.7	De,	2806.6	10.6	De,	2806.6	10.8	O,
	2806.6	10.9	Y,	2807.1	10.5	Ch,	2807.3	10.6	Gi,	2807.4	10.5	L,
	2807.4	10.7	Ja,	2807.4	10.6	Pe,	2807.6	11.1	Pt,	2807.6	10.9	Y,
	2807.6	10.5	Ya,	2808.3	10.8	Pe,	2808.4	10.7	Ja,	2808.5	10.9	Cl,
	2808.5	10.9	O,	2808.5	11.0	Pi,	2808.7	10.9	Pt,	2809.4	10.6	Ja,
	2809.6	10.6	B,	2810.3	10.8	Pe,	2810.4	10.8	Ja,	2810.5	10.8	O,
	2810.6	10.8	B,	2810.7	11.2	Pt,	2811.5	10.8	O,	2811.6	11.0	Pt,
	2811.6	11.0	Cl,	2812.0	11.1	Ym,	2812.6	11.3	B,	2814.3	11.4	Gi,
	2814.4	11.2	L,	2815.4	12.2	Gi,	2815.4	12.7	Pe,	2815.6	12.0	B,
	2815.6	12.0	Pt,	2816.3	12.4	Gi,	2816.3	11.5	L,	2816.3	12.8	Pe,
	2817.4	13.0	Gi,	2817.4	12.5	L,	2817.6	13.5	B,	2818.4	13.4	Gi,
	2818.6	<13.5	B,	2818.7	<12.4	Pt,	2819.3	13.9	Gi,	2821.3	<13.8	Gi,
	2821.6	<12.5	Cl,	2827.6	<10.5	Cl,	2835.4	<12.4	L,	2836.4	<12.4	L,
	2838.4	<12.4	L,	2840.6	<11.5	Pt,	2845.6	<11.5	Pt.			
061647 V AURIGAE—												
	2753.6	11.7	Ba,	2799.6	11.3	B.						
061702 V MONOCEROTIS—												
	2753.6	<13.0	Ba,	2807.6	11.2	Pt.						
063159 U LYNCIS—												
	2756.6	13.2	Ba,	2808.5	<12.4	Pi,	2816.6	13.9	B,	2820.6	12.8	Y,
	2842.6	12.6	Y.									
063308 R MONOCEROTIS—												
	2756.6	<12.0	Ba.									
063558 S LYNCIS—												
	2756.6	13.6	Ba.									
064030 X GEMINORUM—												
	2756.6	13.0	Ba,	2780.5	13.2	Gi,	2807.3	13.0	Gi,	2808.4	12.6	Gi.
064707 W MONOCEROTIS—												
	2807.6	10.9	Pt.									
064932 NOVA GEMINORUM No. 2—												
	2783.3	13.9	L,	2819.4	12.9	L.						
065111 Y MONOCEROTIS—												
	2756.6	12.5	Ba,	2800.6	<10.0	Pw,	2807.6	12.6	Y.			
065208 X MONOCEROTIS—												
	2756.6	8.3	Ba,	2783.3	8.4	L,	2794.3	8.4	L.			

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs
065355 R LYNCIS—								
	2756.6	11.1 Ba,	2780.4	9.8 Gi,	2802.4	8.8 Gi,	2808.6	8.8 Pi,
	2815.6	8.4 B,	2820.6	8.4 Y.	2837.6	7.7 Y,	2842.6	8.1 Y.
070122a R GEMINORUM—								
	2756.6	10.8 Ba,	2762.2	11.2 Ch,	2780.5	12.0 De,	2783.2	<11.5 Ch.
	2783.3	11.8 Pe,	2807.4	12.3 Pe,	2807.6	12.3 Pt,	2809.7	13.0 Lv,
	2812.6	11.9 B.						
070122b Z GEMINORUM—								
	2756.6	12.5 Ba,	2783.3	12.3 Pe,	2807.4	12.5 Pe,	2807.7	12.5 Pt,
	2809.7	12.4 Lv,	2812.6	12.4 B.				
070122c TW GEMINORUM—								
	2756.6	8.0 Ba,	2783.3	7.8 Pe,	2788.3	8.0 Pe,	2807.4	7.9 Pe,
	2809.7	8.4 Lv.						
070109 V CANIS MINORIS								
	2756.6	<13.0 Ba,	2785.0	<10.3 Jk.				
070310 R CANIS MINORIS—								
	2762.6	8.2 Ba,	2783.3	8.4 L,	2785.0	8.5 Jk,	2794.3	8.7 L,
	2800.6	8.6 B,	2805.5	9.5 O,	2814.3	9.1 L.		
070922 U GEMINORUM—								
	2840.6	<12.3 Pt,	2845.6	<11.5 Pt.				
071044 L_2 PUPPIS—								
	2756.1	5.6 Ch.						
071201 RR MONOCEROTIS—								
	2762.6	<13.5 Ba.						
071713 V GEMINORUM—								
	2762.6	<13.4 Ba.						
072708 S CANIS MINORIS—								
	2762.2	10.5 Ch,	2776.2	9.9 Ch,	2780.5	9.6 De,	2781.2	9.8 Ch,
	2783.3	10.1 L,	2783.3	9.9 Pe,	2783.6	10.0 Wm,	2785.0	9.4 Jk,
	2786.3	9.8 Pe,	2786.6	9.7 Wm,	2791.6	9.7 Wm,	2794.3	9.6 L,
	2800.5	9.1 B,	2804.5	9.6 O,	2804.6	9.7 Po,	2804.6	9.7 Wm,
	2806.2	9.5 Ch,	2806.5	9.4 Ya,	2806.6	9.7 Cd,	2807.7	9.1 Pt,
	2810.7	9.5 Bs,	2811.3	9.1 L,	2814.6	9.0 Cd,	2819.6	8.9 Cd,
	2819.6	9.5 Wm,	2826.6	8.5 Wm,	2831.6	8.2 Wm.		
072811 T CANIS MINORIS—								
	2800.6	10.7 B,	2811.6	11.0 Pt.				
073508 U CANIS MINORIS—								
	2782.3	13.0 L,	2794.3	13.2 L,	2806.6	13.0 Y,	2814.3	12.8 L.
073723 S GEMINORUM—								
	2781.3	9.2 Pe,	2782.4	9.1 Pe.	2783.3	9.3 Pe,	2789.4	9.3 Pe,
	2800.6	9.1 B,	2804.6	9.9 Po,	2805.6	9.8 O,	2807.4	10.1 Pe,
	2807.7	9.4 Pt,	2808.4	10.2 Pe,	2818.5	10.1 O,	2819.6	10.1 Gd.
074323 T GEMINORUM—								
	2782.4	9.1 Pe,	2783.3	9.1 Pe,	2789.4	9.1 Pe,	2804.5	8.8 Gd,
	2804.6	8.6 Po,	2805.6	8.9 O,	2806.6	8.6 Ya,	2807.6	8.5 Ml,
	2808.4	9.5 Pe,	2815.6	8.5 B,	2818.5	9.1 O.		
074922 U GEMINORUM—								
	2751.6	<12.3 Rk,	2753.5	14.2 Ba,	2756.4	<13.3 Rk,	2756.6	14.1 Ba,
	2761.2	<12.3 Ch,	2762.5	<13.5 Ba,	2777.2	11.5 Ch,	2780.0	13.1 Ym,
	2780.5	13.7 Gi,	2781.0	<13.3 Ym,	2781.4	13.9 L,	2782.3	13.9 Gi,
	2782.4	13.9 L,	2783.3	13.9 L,	2783.4	<13.3 Ja,	2783.4	13.9 Gi,
	2784.0	<13.3 Ym,	2784.4	13.9 Gi,	2784.4	<13.9 L,	2785.4	<13.3 Ja,
	2786.4	<13.7 Ja,	2788.0	<13.3 Ym,	2791.4	13.9 Gi,	2791.4	13.9 L,
	2792.3	<13.9 L,	2792.4	<13.7 Gi,	2794.3	<12.4 L,	2799.3	<13.3 Gi,
	2801.4	<12.5 L,	2802.3	<13.3 Gi,	2804.3	13.9 Gi,	2805.3	<13.7 Gi,
	2805.5	<13.3 Ym,	2806.6	<13.3 Y.	2807.3	13.9 Gi,	2807.4	<13.3 Ja,
	2807.7	<13.3 Pt,	2808.4	<13.3 Ja,	2810.4	<13.3 Ja,	2810.6	<13.7 B,
	2810.7	<13.3 Pt,	2811.3	<13.7 L,	2811.6	<13.3 Pt,	2812.0	<13.3 Ym,
	2814.4	<13.7 Gi,	2815.5	13.9 Gi,	2815.6	<13.3 Pt,	2816.3	13.9 Gi,
	2816.3	14.0 L,	2817.4	13.9 Gi,	2817.4	<13.3 L,	2817.6	14.0 B,
	2818.4	13.9 Gi,	2818.4	<13.3 L,	2819.3	13.9 Gi,	2819.3	<13.7 L,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
074922 U GEMINORUM—												
	2819.6	<13.7	Du,	2820.6	<13.3	Y,	2821.3	13.7	L,	2821.4	<13.7	Gi,
	2821.6	<13.0	Du,	2823.8	<13.3	Wf,	2828.3	<12.3	L,	2834.6	<13.7	B,
	2835.3	<12.4	L,	2836.4	<12.4	L,	2836.6	<12.4	Y,	2838.4	<12.4	L,
	2840.6	<12.3	Pt,	2845.6	<11.5	Pt.						
081112 R CANCRI—												
	2751.5	7.6	Rk,	2758.4	7.7	Rk,	2759.1	8.5	Ch,	2776.2	7.8	Ch,
	2782.4	7.8	L,	2785.0	8.4	Jk,	2787.2	7.7	Ch,	2792.3	8.1	L,
	2800.6	8.2	B,	2805.6	8.7	O,	2805.7	7.3	Cg,	2806.6	8.7	Po,
	2806.6	8.6	Ya,	2807.6	8.5	Gd,	2807.7	8.5	Pt,	2811.7	8.6	Bs,
	2814.4	8.7	L,	2819.4	8.2	Rk,	2819.5	8.8	O,	2819.8	8.6	Cg,
	2820.4	8.3	Rk.									
081617 V CANCRI—												
	2780.5	7.9	Gi,	2783.4	8.3	Ja,	2792.4	7.9	Gi,	2800.6	8.2	B,
	2805.6	8.0	O,	2806.4	8.1	Ja,	2806.6	7.8	Po,	2807.4	7.9	Gi,
	2807.6	7.8	Gd,	2807.7	7.6	Pt,	2818.5	8.0	O,	2819.4	8.0	Gi,
	2840.6	8.5	Pt.									
082405 RT HYDRAE—												
	2783.4	8.1	L,	2794.3	8.1	L,	2814.3	7.4	L.			
083019 U CANCRI—												
	2840.7	<12.4	Wf.									
083350 X URSAE MAJORIS—												
	2805.6	10.3	Du,	2805.7	9.6	Cg,	2807.7	10.5	Pt,	2808.6	10.5	Pi,
	2818.6	11.1	B,	2819.6	11.1	Du,	2819.6	11.0	Ya,	2819.8	<9.6	Cg,
	2820.6	11.5	O,	2834.6	12.0	B,	2836.6	<9.6	Cg,	2845.6	12.3	Pt,
	2853.6	<9.0	Cg.									
084803 S HYDRAE—												
	2764.2	<11.8	Ch,	2781.2	<11.0	Ch,	2804.6	11.5	Gd,	2804.6	11.8	Ya,
	2810.7	11.1	Pt,	2820.6	11.3	Gd,	2835.6	10.6	B,	2840.6	10.7	Pt.
085008 T HYDRAE—												
	2764.2	<11.0	Ch,	2781.2	11.2	Ch,	2782.3	10.6	L,	2791.4	10.6	L,
	2807.2	9.7	Ch,	2810.7	9.6	Pt.						
085120 T CANCRI—												
	2783.4	8.1	L,	2794.3	8.1	L,	2807.7	9.0	Pt,	2814.4	8.4	L,
	2819.5	9.3	O,	2821.6	9.0	Hs,	2835.4	8.0	L.			
090151 V URSAE MAJORIS—												
	2789.4	10.6	Pe,	2806.4	10.8	Pe,	2808.6	11.0	Pi,	2840.3	10.8	Pe,
	2845.6	10.4	B.									
090425 W CANCRI—												
	2762.6	11.6	Ba,	2791.4	13.2	L,	2814.4	<11.0	L,	2840.7	<12.6	Wf.
093014 X HYDRAE—												
	2762.6	8.9	Ba,	2804.6	10.4	Ya,	2806.6	10.6	De.			
093178 Y DRACONIS—												
	2762.6	13.1	Ba,	2805.7	<13.1	Du,	2820.6	13.6	Y,	2821.7	<14.0	Du,
	2837.6	<13.0	Y.									
093934 R LEONIS MINORIS—												
	2762.6	7.3	Ba,	2765.1	7.7	Ch,	2784.3	7.2	L,	2785.2	7.8	Ch,
	2801.5	8.9	L,	2804.7	9.2	M,	2804.7	9.4	Po,	2807.2	9.4	Ch,
	2807.7	9.2	Pt,	2819.4	9.6	L,	2819.6	9.9	Ya,	2821.6	9.3	Hs,
	2834.6	9.6	B,	2837.7	10.4	Pt,	2839.4	10.9	L,	2840.6	9.7	Hs,
	2840.6	10.2	Po,	2841.6	10.6	Ba,	2842.6	9.6	B,	2849.7	10.6	Bs.
094211 R LEONIS—												
	2750.5	7.5	Rk,	2752.5	7.3	Rk,	2757.4	7.4	Rk,	2762.6	6.7	Ba,
	2765.1	7.5	Ch,	2767.4	7.6	Rk,	2771.4	8.0	Rk,	2782.4	8.1	Pe,
	2784.0	8.1	Ym,	2785.2	8.4	Ch,	2786.6	7.7	Wm,	2789.4	8.7	Pe,
	2791.6	8.0	Wm,	2799.6	8.0	Wm,	2804.5	9.3	O,	2804.6	8.7	Wm,
	2804.7	8.4	M,	2805.5	8.1	Cl,	2805.7	9.0	Cg,	2807.5	8.7	Cg,
	2807.6	8.8	Ya,	2807.7	8.7	Pt,	2809.8	8.5	Bs,	2810.3	8.9	Pe,
	2810.5	9.0	O,	2816.6	8.8	Wm,	2817.5	8.7	Ro,	2818.8	9.7	Cg,
	2819.5	9.5	Ro,	2819.6	8.9	Wm,	2820.4	8.5	Rk,	2820.6	8.7	Hm,
	2820.6	8.7	Hs,	2821.6	9.1	Cl,	2821.6	9.0	Hs,	2826.6	9.0	Wm,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
094211 R LEONIS—												
	2827.6	9.3	Cl,	2829.4	9.1	Rk,	2831.6	9.2	Wm,	2832.7	8.8	Bs,
	2836.6	9.6	Ca,	2836.6	<9.6	Cg,	2837.6	9.9	Cl,	2837.7	9.5	Pt,
	2838.4	9.2	Rk,	2840.6	10.0	Hs,	2840.6	9.5	O,	2840.6	9.8	Po.
	2840.6	9.3	Wm,	2841.6	9.5	Ba,	2842.6	9.5	B,	2842.6	9.8	Cl,
	2842.6	10.0	Gd,	2842.6	9.8	Wm,	2845.6	9.9	Wm,	2849.6	10.0	Wm,
	2849.7	9.6	Bs,	2855.6	10.1	Wl,	2855.6	10.2	Wm.			
094512 X LEONIS—												
	2781.4	12.2	L,	2782.3	12.3	L,	2783.3	14.1	L,	2784.0	<13.3	Ym,
	2784.3	<14.2	L,	2791.4	<13.9	L,	2792.3	<13.9	L,	2794.4	12.7	L,
	2807.4	<14.2	L,	2814.3	<14.5	L,	2816.3	<14.2	L,	2817.3	<13.9	L,
	2818.3	<13.9	L,	2819.3	<14.2	L,	2821.3	<13.9	L,	2835.4	<13.0	L,
	2836.4	<13.0	L,	2838.4	<13.0	L,	2839.4	<13.0	L,	2840.4	<12.3	L.
094622 Y HYDRAE—												
	2804.6	7.3	Ya,	2811.6	7.0	Pt.						
095421 V LEONIS—												
	2762.6	8.6	Ba,	2782.4	9.9	Pe,	2783.4	9.5	Ja,	2789.4	9.7	Pe,
	2804.7	9.8	M,	2805.4	10.1	Pe,	2805.6	10.6	O,	2806.4	10.3	Ja,
	2807.7	10.4	Pt,	2810.3	10.4	Pe,	2818.5	10.9	O,	2820.6	11.0	Hm,
	2820.6	11.2	Hs,	2821.6	11.1	Hs,	2823.6	11.0	B,	2833.7	12.4	Wf,
	2841.6	12.3	Ba,	2842.6	12.3	B,	2844.7	12.4	Wf,	2845.6	12.4	Pt,
	2852.7	<11.8	Wf.									
103212 U HYDRAE—												
	2781.3	5.8	Pe,	2782.4	5.8	Pe,	2784.3	5.0	L,	2785.4	5.7	Pe,
	2793.4	5.7	Pe,	2806.4	5.7	Pe,	2710.4	5.8	Pe,	2815.3	5.6	Pe,
	2816.4	5.0	L.									
103769 R URSAE MAJORIS—												
	2756.6	11.2	Ba,	2762.3	11.5	Ch,	2785.2	<11.5	Ch,	2799.6	11.0	Wm,
	2805.7	12.5	Du,	2808.6	<11.5	Pi,	2809.5	11.0	Ro,	2815.8	12.8	Pt.
	2816.8	11.1	M,	2819.6	12.0	Wm,	2819.6	12.5	Ya,	2821.6	12.8	Du,
	2824.8	<11.5	Bs,	2826.6	12.5	M,	2827.6	<11.0	Cl,	2835.6	13.0	B,
	2840.3	<12.0	Pe,	2840.6	12.8	Ba,	2840.6	<12.5	M,	2845.6	13.1	Pt,
	2852.7	13.0	Bs,	2853.7	<10.5	Ca.						
104620 V HYDRAE—												
	2762.2	8.1	Ch,	2776.2	7.8	Ch,	2784.3	6.9	L,	2785.0	7.3	Ch,
	2797.2	7.1	Ch,	2802.4	6.7	L,	2806.2	7.7	Ch,	2807.7	6.0	Pt,
	2819.4	7.0	L,	2819.6	7.6	Ya,	2845.6	6.5	Pt.			
104814 W LEONIS—												
	2807.7	12.4	Pt,	2820.6	12.5	Y,	2834.6	12.9	B,	2837.6	12.7	Y.
110506 S LEONIS—												
	2819.6	<13.0	Du,	2835.6	11.7	B.						
115919 R COMAE BERNICES—												
	2756.6	<12.5	Ba,	2787.5	<13.0	Ja,	2809.4	11.3	Ja,	2820.6	9.7	Ya,
	2823.9	9.2	Wf,	2833.7	8.1	Wf,	2835.8	8.8	Wf,	2839.6	8.7	Ba,
	2840.6	8.3	Cd,	2840.6	8.8	Ya,	2841.6	8.8	O,	2842.6	8.8	B,
	2844.7	8.0	Wf,	2849.6	8.7	O,	2850.7	8.5	Wf.			
120012 SU VIRGINIS—												
	2762.6	<13.0	Ba,	2839.6	<12.0	Hl,	2845.6	12.3	B.			
120905 T VIRGINIS—												
	2762.6	<12.7	Ba,	2839.6	<12.0	Hl,	2845.6	<14.0	B.			
121418 R CORVI—												
	2762.6	10.8	Ba,	2783.4	10.6	L,	2786.4	10.1	Ja,	2794.4	<9.7	L,
	2804.6	9.0	Ya,	2806.6	9.0	Po,	2807.4	8.9	Pe,	2807.5	9.1	L,
	2810.4	8.8	Pe,	2810.5	8.6	Ja,	2815.4	8.8	Pe,	2815.6	8.4	Pt,
	2817.4	8.6	Pe,	2819.4	8.4	L,	2819.6	8.3	Gd,	2837.7	8.0	Pt,
	2839.4	7.9	Pe,	2839.4	8.1	L,	2839.6	7.8	Ba,	2839.6	8.8	Hl,
	2839.7	7.9	M,	2840.4	7.8	Pe,	2842.6	8.0	Gd,	2843.6	8.0	Ya,
	2852.6	7.3	B.									
122001 SS VIRGINIS—												
	2791.4	7.9	L,	2804.7	9.2	M,	2806.6	9.6	O,	2816.4	8.2	L,
	2835.4	7.6	L.									

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
122532 T CANUM VENATICORUM—												
	2756.6	10.1	Ba,	2799.7	11.0	Bs,	2803.8	10.4	M,	2804.6	10.5	Ya,
	2806.6	10.5	De,	2809.7	10.7	Bs,	2815.6	11.0	Pt,	2830.6	<10.0	Pw,
	2837.7	11.0	Pt,	2840.6	11.3	Ya,	2841.6	11.1	Ba,	2841.6	<10.0	Hl,
	2842.6	9.8	Wl,	2853.6	11.5	M.						
122803 Y VIRGINIS—												
	2762.6	<13.0	Ba,	2782.4	<13.2	L,	2816.4	12.6	L,	2839.4	11.8	L,
	2839.6	<11.0	Hl,	2840.6	<10.3	Ya,	2841.6	11.7	Ba,	2845.6	11.3	B.
123160 T URSAE MAJORIS—												
	2754.1	7.9	Ch,	2756.6	8.3	Ba,	2775.1	6.9	Ch,	2781.3	6.9	Pe,
	2783.3	6.8	Pe,	2797.2	6.7	Ch,	2799.7	7.0	Bs,	2804.5	7.3	O,
	2804.7	7.3	Po.	2805.0	7.6	Ym,	2806.2	7.2	Ch,	2806.6	7.6	Cd,
	2807.6	7.3	Gd,	2808.5	7.3	Cl,	2809.5	7.0	Ro,	2810.8	7.3	M,
	2811.8	7.6	Cg,	2813.8	6.9	Bs,	2814.5	7.7	Cd,	2815.8	7.5	Pt,
	2817.5	8.0	Ro,	2819.6	7.6	Cd,	2819.6	7.9	Ya,	2819.8	8.1	Cg,
	2821.7	7.6	Du,	2826.8	8.1	M,	2827.6	8.0	Cd,	2834.6	8.2	Cd,
	2836.6	8.5	B,	2836.6	8.8	Cg,	2837.7	8.5	Pt,	2840.6	8.6	Ba,
	2840.6	9.0	M,	2840.6	9.0	Po,	2840.7	9.8	My	2841.6	8.4	Hl,
	2841.6	9.0	M,	2842.0	9.0	O,	2845.6	9.1	Cd,	2849.6	9.3	Gd,
	2849.6	9.3	O,	2852.7	9.6	Bs,	2853.6	9.3	Cg,	2853.7	9.6	Ca,
	2856.6	10.0	O.									
123307 R VIRGINIS—												
	2762.7	7.5	Ba,	2783.4	6.9	Pe,	2784.3	6.6	L,	2785.4	7.1	Pe,
	2801.5	7.6	L,	2804.6	8.2	O,	2804.8	8.2	M,	2805.6	8.1	Gd,
	2805.8	7.8	Bs,	2806.4	8.4	Pe,	2806.6	8.4	Po,	2807.7	8.2	Pt,
	2811.5	8.4	O,	2818.6	8.9	Lc,	2819.4	9.3	L,	2820.6	9.0	Gd,
	2830.6	<10.0	Pw,	2836.6	<10.6	Ca,	2837.6	<9.6	Cg,	2837.7	10.4	Pt,
	2839.4	10.5	Pe,	2839.6	10.3	Lc,	2840.4	10.3	L,	2840.6	10.3	Po,
	2841.6	10.9	Ba,	2843.8	10.3	Bs,	2846.6	10.5	Cd,	2846.6	11.0	O.
123459 RS URSAE MAJORIS—												
	2756.6	<13.2	Ba,	2763.2	<11.5	Ch,	2783.1	<11.5	Ch,	2804.7	<10.8	Po,
	2805.5	<13.2	Ym,	2808.5	11.0	Cl,	2811.8	<9.9	Cg.	2816.8	13.4	M,
	2819.8	<9.9	Cg,	2821.7	<13.7	Du,	2833.7	<13.7	Wf,	2836.6	<14.0	B,
	2839.8	<13.7	Wf,	2840.6	14.2	Ba,	2841.6	<12.0	Hl,	2841.6	<11.3	Ya,
	2848.7	<13.7	Wf,	2853.6	<9.5	Cg.						
123961 S URSAE MAJORIS—												
	2756.6	8.3	Ba,	2763.2	10.5	Ch,	2775.1	10.8	Ch,	2782.4	11.1	L,
	2783.2	11.4	Ch,	2792.3	11.8	L,	2799.8	11.2	Bs,	2804.7	<10.3	Po,
	2807.6	11.3	De,	2807.6	11.2	Gd,	2808.5	11.3	Cl.	2809.5	11.1	Ro,
	2811.8	<9.9	Cg,	2813.7	11.5	Bs,	2815.8	11.3	Pt,	2816.6	11.0	L,
	2817.5	10.8	Ro,	2819.6	10.9	Ya,	2819.8	<9.9	Cg,	2821.6	11.2	Hs,
	2821.7	10.4	Du,	2826.8	10.0	M,	2836.6	8.7	B,	2836.6	9.6	Cg,
	2837.7	9.0	Pt,	2838.4	8.5	L,	2840.6	8.3	Ba,	2840.6	8.6	Hs,
	2840.6	8.8	Po,	2841.6	8.6	Ya,	2842.6	8.6	O.	2849.6	8.4	Gd,
	2849.6	8.2	O,	2852.7	8.5	Bs,	2853.6	8.0	Cg,	2856.6	8.2	O.
124204 RU VIRGINIS—												
	2762.7	<13.0	Ba,	2807.5	<12.8	Ja,	2810.8	<11.6	M,	2841.6	13.5	Ba,
	2845.6	13.4	B.									
124606 U VIRGINIS—												
	2762.7	<12.1	Ba,	2783.4	10.4	Ja,	2785.4	9.9	Pe,	2804.6	9.2	O,
	2804.6	9.4	Ya,	2806.4	9.1	Pe,	2807.4	9.4	Ja,	2807.7	8.5	Pt,
	2819.6	8.6	B,	2839.4	8.8	Pe,	2840.6	7.4	Pw,	2840.7	8.5	Pt,
	2841.6	8.4	Ba,	2841.6	7.8	Hl,	2841.6	8.7	Ya,	2842.6	8.4	B,
	2842.6	8.7	O,	2849.7	8.1	Bs,	2853.6	8.4	M.			
130212 RV VIRGINIS—												
	2762.7	11.1	Ba.	2834.7	<13.6	Wf.	2840.6	<12.1	Pw,	2841.6	<13.0	Hl,
	2844.7	<13.6	Wf.									
132002 W VIRGINIS—												
	2762.7	9.4	Ba.									
132202 V VIRGINIS—												
	2762.7	9.9	Ba,	2841.6	<13.0	Hl.						

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
132422 R HYDRAE—												
	2761.2	8.1	Ch,	2781.5	8.0	L,	2783.6	8.5	Gd,	2785.2	9.1	Ch,
	2802.4	8.8	Gi,	2807.2	9.4	Ch,	2807.5	9.1	L,	2807.7	8.6	Pt,
	2811.8	9.2	Bs,	2818.6	9.8	Lc,	2819.4	9.5	Gi,	2825.7	9.4	Bs,
	2834.6	9.9	Lc,	2839.4	9.5	Gi,	2839.6	9.9	Lc,	2840.7	9.6	Pt,
	2853.7	10.2	Bs.									
132706 S VIRGINIS—												
	2759.2	6.9	Ch,	2777.2	7.3	Ch,	2804.7	8.6	M,	2805.6	8.8	Gd,
	2807.7	9.0	Pt,	2808.6	8.9	O,	2812.7	9.0	Mu,	2818.5	9.0	O,
	2820.6	9.0	Gd,	2820.6	9.3	Ya,	2836.6	9.6	Ca,	2837.6	<9.4	Cg,
	2840.7	9.8	Pt,	2841.6	9.9	Ba,	2841.6	10.0	Hl,	2843.6	9.7	Ya,
	2846.6	10.5	O,	2848.8	10.2	Bs.						
133273 T URSAE MINORIS—												
	2756.6	<12.4	Ba,	2805.7	<12.8	Du,	2821.6	<13.5	Du,	2840.6	11.6	Pw,
	2841.6	<13.0	Hl,	2844.8	<12.8	Wf,	2848.8	<12.8	Wf,	2849.8	<12.8	Wf.
134440 R CANUM VENATICORUM—												
	2756.6	9.4	Ba,	2803.8	8.4	M,	2805.5	8.3	O,	2806.6	8.1	Po,
	2809.5	7.8	Ro,	2809 7	8.4	Bs,	2811.6	7.6	Lv,	2811.6	7.4	Pt,
	2817.5	7.5	Ro,	2819.5	7.8	O,	2819.6	7.6	Gd,	2820.6	7.6	Ya,
	2821.6	7.8	Wm,	2836.6	7.5	Wm,	2837.7	7.2	Pt,	2841.6	7.5	Ba,
	2843.6	7.4	Po,	2843.6	7.6	Ya,	2844.8	7.9	M.			
135908 RR VIRGINIS—												
	2841.6	<13.0	Hl.									
140113 Z BOOTIS—												
	2805.6	10.0	Y,	2817.6	9.1	B,	2834.8	9.5	Wf,	2840.6	9.6	Pw,
	2841.6	9.7	Ba,	2841.6	10.6	Hl,	2842.6	9.7	Y,	2843.6	9.7	O,
	2843.7	10.2	Wf,	2850.7	10.1	Wf,	2853.6	9.9	M.			
140512 Z VIRGINIS—												
	2841.6	<13.0	Hl,	2844.6	<13.0	Pw,	2849.6	<13.5	B.			
141567 U URSAE MINORIS—												
	2756.6	10.1	Ba,	2761.2	10.0	Ch,	2775.1	9.6	Ch,	2787.2	9.0	Ch,
	2803.8	8.8	M,	2805.7	8.7	Du,	2806.2	8.2	Ch,	2806.6	8.6	De,
	2806.7	8.6	Po,	2808.5	8.3	O,	2809.5	8.5	Ro,	2811.6	8.6	Po,
	2817.6	8.4	Lv,	2821.7	7.7	Du,	2840.6	8.3	Hs,	2841.6	7.9	Ba,
	2841.6	8.1	O,	2843.6	8.2	Po,	2844.6	8.8	Hl.	2844.6	8.8	Pw,
	2850.6	8.4	Ya,	2850.8	8.3	Pt,	2853.6	8.4	M,	2854.8	8.3	Ka.
141954 S BOOTIS—												
	2756.6	9.5	Ba,	2764.2	9.7	Ch,	2777.2	10.3	Ch,	2782.4	10.3	Gi,
	2782.4	10.3	L,	2788.2	10.7	Ch,	2790.6	10.5	L,	2800.6	<10.0	Pw,
	2802.4	11.1	Gi,	2803.8	11.2	M,	2806.5	11.0	Cl,	2806.6	11.4	De,
	2806.7	<10.6	Po,	2808.5	11.3	O,	2808.8	10.4	Bs,	2811.6	11.8	Pt,
	2814.4	11.6	L,	2816.4	11.7	Gi,	2817.5	11.5	Ro,	2820.6	12.0	Ya,
	2821.6	<11.0	Cl,	2840.4	12.4	L,	2840.5	12.5	Gi,	2841.6	12.7	Ba,
	2850.8	12.7	Pt,	2853.6	<12.0	M.						
142205 RS VIRGINIS—												
	2807.4	9.5	Ja,	2808.6	8.6	O,	2841.6	9.5	Ba,	2842.6	9.5	O.
142584 R CAMELOPARDALIS—												
	2756.6	12.2	Ba,	2782.4	13.2	Gi,	2815.4	<12.7	Gi,	2836.6	12.1	B,
	2839.9	11.4	Wf,	2840.5	11.9	Gi,	2844.6	<10.5	Pw,	2848.7	11.1	Wf,
	2849.6	<13.0	Hl.									
142539 V BOOTIS—												
	2756.6	10.0	Ba,	2784.3	10.5	L,	2803.8	9.9	M,	2806 6	9.5	De,
	2806.7	9.6	Po,	2809.5	9.8	Ro,	2811.6	9.5	Pt,	2814.4	9.6	L,
	2819.5	9.3	Ro,	2819.6	10.6	Gd,	2826.6	9.8	Pw,	2838.4	8.1	L,
	2840.6	8.4	Wl,	2840.7	8.0	Po,	2841.6	8.0	Ba,	2842.8	7.8	Ca,
	2843 8	8.2	M,	2844.6	9.1	Hl,	2844.6	9.1	Pw,	2847.6	7.8	Ya,
	2850.8	7.8	Pt.	2850.9	7.8	Ka,	2853.6	7.7	Gd.			
143227 R BOOTIS—												
	2753.3	11.5	Ch,	2777.3	9.1	Ch,	2785.4	8.6	Pe,	2787.2	8.5	Ch,
	2800.6	9.2	Pw,	2803.8	7.4	M,	2804.5	7.0	Mo,	2804.6	7.2	O,
	2805.4	7.5	Pe,	2806.2	7.5	Ch,	2806.7	7.4	De,	2809.7	7.8	Bs,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
143227 R BOOTIS—												
	2810.5	7.1	O,	2810.7	7.3	Po,	2810.8	7.7	Bs,	2811.6	7.1	Pt,
	2818.5	7.1	O,	2819.5	7.1	Mo,	2820.6	8.0	Wm,	2820.6	7.5	Ya,
	2824.7	7.4	Bs,	2835.7	7.4	Bs,	2836.6	7.5	Wm,	2840.6	7.1	Hs,
	2840.6	7.3	O,	2840.6	7.6	Wl,	2840.7	8.5	My,	2841.6	7.5	Ba,
	2842.8	7.7	Ca,	2843.6	7.3	O,	2843.6	7.2	Po,	2843.6	7.8	Wm,
	2843.7	8.3	My	2843.8	7.0	M,	2845.6	7.5	Wm,	2847.6	7.9	Ya,
	2849.6	8.2	Hl,	2849.6	7.3	O,	2849.6	7.8	Wm,	2850.6	7.1	Mo,
	2850.8	7.4	Pt,	2855.6	7.8	Wm.						
143417 V LIBRAE—												
	2840.6	12.3	Ba,	2843.6	12.0	Y,	2845.6	11.3	O,	2849.7	10.8	B.
144918 U BOOTIS—												
	2780.6	12.0	Gi,	2816.4	11.6	Gi,	2818.8	11.7	M,	2819.6	12.1	B,
	2826.6	<11.0	Pw,	2840.5	11.0	Gi,	2841.6	11.0	Ba,	2844.8	10.8	M.
150018 RT LIBRAE—												
	2782.6	<11.9	Ja,	2786.5	<13.2	Ja,	2807.5	<12.9	Ja,	2817.8	11.4	M,
	2819.6	9.8	Cd,	2840.6	10.0	Ba,	2842.6	9.5	Cd,	2843.6	9.7	Y,
	2845.7	9.0	Pt,	2849.7	9.3	B.						
150519 T LIBRAE—												
	2782.6	11.6	Ja,	2807.5	11.2	Ja,	2811.6	11.3	Pt,	2817.8	11.2	M,
	2826.6	<10.0	Pw,	2840.6	12.8	Ba,	2840.6	12.7	B,	2845.7	12.4	Pt.
150605 Y LIBRAE—												
	2782.6	11.3	L,	2786.5	10.4	Ja,	2807.5	8.9	Ja,	2811.6	9.1	Pt,
	2816.4	9.0	L,	2835.4	9.4	L,	2840.6	9.2	Ba,	2843.6	9.4	Ya,
	2845.7	9.5	Pt,	2850.6	9.7	O.						
151520 S LIBRAE—												
	2753.3	9.0	Ch,	2781.3	8.8	Ch,	2790.6	8.5	L,	2797.2	8.4	Ch,
	2806.8	8.6	Ml,	2811.7	8.5	Pt,	2816.5	8.6	L,	2835.4	9.2	L,
	2845.7	9.5	Pt.									
151731 S CORONAE BOREALIS—												
	2761.2	8.0	Ch,	2783.4	9.3	Pe,	2785.4	9.5	Pe,	2786.6	10.0	Wm,
	2788.2	9.5	Ch,	2804.6	10.5	Wm,	2806.6	9.8	Cd,	2807.1	10.0	Ch,
	2807.4	10.1	Pe,	2807.7	10.1	Pt,	2810.7	10.2	Po,	2812.7	10.6	Mu,
	2815.4	10.1	Pe,	2818.8	10.0	M,	2819.6	10.5	Wm,	2834.7	10.9	Mu,
	2840.7	10.9	Po,	2841.6	11.0	Ba,	2841.6	11.0	Pt,	2841.6	11.0	Y,
	2843.8	11.0	M,	2856.6	11.3	Ya.						
151714 S SERPENTIS—												
	2791.4	13.4	L,	2809.6	12.4	Ja,	2816.5	12.2	L,	2823.9	12.1	Wf,
	2838.4	12.1	L,	2840.6	<10.5	Ca,	2840.8	12.1	Wf,	2848.8	12.0	Wf,
	2853.6	11.4	M.									
151822 RS LIBRAE—												
	2782.6	9.0	L,	2816.5	10.5	L,	2836.4	11.4	L,	2855.6	11.8	B.
152714 RU LIBRAE—												
	2782.6	<12.5	Ja,	2784.6	<13.1	L,	2807.5	12.5	Ja,	2816.4	12.3	L,
	2821.7	<11.0	Mu,	2834.7	11.4	Mu,	2836.4	11.9	L,	2840.6	11.5	Ba,
	2840.6	11.5	B,	2843.6	11.7	Ya,	2845.7	11.9	Pt,	2849.6	<11.0	Po,
	2853.6	10.9	Gd.									
153215 W LIBRAE—												
	2840.6	10.4	Ba,	2849.6	<11.0	Po.						
153378 S URSAE MINORIS—												
	2804.6	10.5	Wm,	2809.5	10.8	Ro,	2810.7	10.6	Po,	2814.7	10.7	Bs,
	2815.6	10.3	Pt,	2817.5	10.5	Ro,	2820.6	10.5	Wm,	2836.6	10.6	Wm,
	2839.8	9.7	Wf,	2841.6	10.0	Ba.	2842.6	10.6	Wm,	2844.8	9.6	M,
	2846.6	10.8	Su,	2848.7	9.8	Wf,	2849.6	10.2	Wm,	2850.6	10.2	Po,
	2850.6	9.6	Ya,	2850.9	10.4	Ja,	2855.6	9.5	Hl,	2855.6	9.5	Pw.
154428 R CORONAE BOREALIS—												
	2753.3	7.7	Ch,	2755.3	7.2	Ch,	2756.3	7.3	Ch,	2759.2	7.2	Ch,
	2761.2	7.8	Ch,	2762.2	8.0	Ch,	2762.7	8.0	Ba,	2764.2	8.4	Ch,
	2765.2	8.5	Ch,	2767.2	9.3	Ch,	2775.3	7.8	Ch,	2776.2	7.6	Ch,
	2777.3	7.4	Ch,	2779.3	7.0	Ch,	2780.6	6.8	Gi,	2781.3	6.8	Ch,
	2781.4	6.9	L,	2781.4	6.9	Pe,	2782.4	6.9	Gi,	2782.6	6.7	Ja,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
154428 R CORONAE BOREALIS—												
	2782.6	6.6	L,	2783.4	6.5	L,	2783.4	6.8	Pe,	2784.0	7.0	Ym,
	2784.4	6.5	L,	2784.6	6.6	Gl,	2784.6	6.5	Mt,	2785.4	6.9	Pe,
	2785.5	6.7	Ja,	2786.5	6.4	Pe,	2786.6	7.0	Wm,	2789.4	6.2	Pe,
	2790.2	6.0	Ch,	2790.6	6.1	L,	2791.4	6.2	L,	2791.6	7.0	Wm,
	2792.3	6.0	L,	2794.4	6.2	L,	2796.4	6.1	Pe,	2798.4	6.2	Pe,
	2798.7	6.5	Bs,	2799.4	6.1	L,	2799.6	6.1	Pt,	2799.6	6.2	Wm,
	2800.7	6.1	Du,	2801.4	6.1	L,	2803.4	6.2	Pe,	2803.7	6.1	Pt,
	2803.8	6.2	M,	2804.5	6.0	O,	2804.5	6.1	Mo,	2804.6	6.2	Wm,
	2804.7	6.6	Mu,	2804.8	6.2	M,	2805.5	6.1	O,	2805.6	6.8	Cl,
	2805.6	6.8	Gd,	2805.7	5.8	Cg,	2805.8	6.0	Du,	2806.4	6.0	Pe,
	2806.6	6.6	Cl,	2806.7	6.5	De,	2807.1	6.0	Ch,	2807.4	6.9	L,
	2807.4	6.1	Mt,	2807.4	6.0	Pe,	2807.5	6.1	Gi,	2807.7	6.2	Bs,
	2807.7	6.1	Pt,	2807.7	6.5	Mu,	2808.6	6.1	O,	2808.7	6.0	Bs,
	2808.7	5.7	Cg,	2808.7	6.1	Pt,	2809.5	6.5	Ro,	2809.6	6.2	Ja,
	2810.3	5.9	Pe,	2810.5	6.1	O,	2810.7	6.1	Pt,	2811.6	6.0	Cd,
	2811.6	6.4	Cl,	2811.7	6.0	Pt,	2813.0	5.8	Nk,	2814.4	6.3	L,
	2814.8	5.9	Bs,	2815.4	5.9	Pe,	2816.4	6.2	Gi,	2816.4	6.2	L,
	2816.6	6.5	Wm,	2816.7	6.1	Pt,	2816.8	6.2	M,	2817.4	6.1	L,
	2817.5	6.2	Ro,	2817.8	6.2	M,	2818.1	6.0	Nk,	2818.4	6.1	L,
	2818.5	6.2	O,	2818.7	6.5	Mu,	2818.7	6.9	Lc,	2818.7	6.2	Pt,
	2819.4	6.1	L,	2819.5	6.1	O,	2819.5	6.2	Mo,	2819.6	6.0	Cd,
	2819.6	6.0	Ya,	2819.7	5.8	Bs,	2819.7	6.1	Du,	2819.8	5.7	Cg,
	2820.6	6.0	L,	2820.6	6.1	O,	2820.7	6.4	Mu,	2820.8	6.1	Pt,
	2821.5	6.2	Gi,	2821.5	6.1	L,	2821.6	6.9	Cl,	2821.6	6.1	Du,
	2821.6	6.2	Hm,	2821.6	6.2	Hs,	2821.6	5.8	Hs,	2822.7	5.9	Bs,
	2822.7	6.3	Mu,	2823.2	6.0	Nk,	2823.7	5.2	Pt,	2824.1	6.0	Nk,
	2824.7	6.2	Bs,	2825.4	6.1	L,	2826.6	6.2	Wm,	2826.8	6.2	Pt,
	2827.6	6.3	Cl,	2827.6	6.2	O,	2831.6	6.2	Wm,	2833.8	6.0	Wf,
	2834.7	6.2	Mu,	2835.6	6.5	Cg,	2835.8	5.9	Bs,	2835.8	6.0	Wf,
	2836.4	6.1	L,	2836.6	6.3	Ca,	2836.6	6.4	Wm,	2837.1	6.3	Nk,
	2837.6	7.1	Cl,	2837.7	6.3	Pt,	2838.4	6.3	L,	2838.6	6.2	M,
	2839.3	6.3	Pe,	2839.4	6.3	L,	2839.6	6.9	Lc,	2839.7	6.1	M,
	2839.7	6.0	Ba,	2839.8	6.3	Pt,	2840.4	6.3	L,	2840.6	6.1	Ba,
	2840.6	6.6	Wm,	2840.6	6.5	B,	2840.6	6.0	M,	2840.6	6.7	Cl,
	2840.7	6.4	Ca,	2840.7	6.3	Pt,	2840.7	7.0	My,	2841.4	6.7	Gi,
	2841.6	6.0	Ba,	2841.6	6.5	O,	2841.7	6.4	Pt,	2841.7	6.5	Mu,
	2841.7	6.9	My,	2842.6	6.6	Cl,	2842.6	6.7	O,	2842.6	6.8	Wm,
	2843.6	6.7	O,	2843.6	6.7	Po,	2843.6	6.8	Wm,	2843.7	6.5	Mu,
	2843.7	6.9	My,	2843.8	7.3	M,	2844.6	7.0	Mo,	2844.6	6.7	O,
	2844.7	6.1	Bs,	2844.8	7.0	M,	2844.8	7.2	Wf,	2845.6	7.0	Cl,
	2845.6	6.7	O,	2845.6	7.0	Cg,	2845.6	7.0	Wm,	2845.7	6.4	Pt,
	2846.6	6.3	Pt,	2846.7	6.3	Mu,	2847.7	6.5	Mu,	2848.6	6.7	Cl,
	2849.6	7.4	O,	2849.6	7.3	Gd,	2849.6	7.4	Mo,	2849.6	7.0	Po,
	2849.6	7.0	Wm,	2849.7	7.4	Bs,	2849.7	6.7	Mu,	2850.6	7.1	Hs,
	2850.6	7.5	O,	2850.6	7.2	Po,	2850.7	7.1	Mu,	2850.7	7.1	Wf,
	2850.8	7.4	M,	2850.8	7.6	Pt,	2850.9	7.4	Ka,	2851.6	7.3	Y,
	2851.8	7.7	M,	2852.8	7.7	Pt,	2853.6	6.9	Cg,	2853.6	7.3	Gd,
	2853.6	7.7	M,	2853.8	7.7	Ca,	2854.6	7.5	Gd,	2854.8	7.9	Pt,
	2854.8	7.3	M,	2855.6	7.4	Cl,	2855.6	7.5	O,	2855.6	7.2	Wm,
	2855.7	7.5	Bs,	2855.7	7.5	Ca,	2855.7	7.3	Po,	2856.6	7.5	Gd,
	2856.6	7.5	O,	2856.6	7.2	Po,	2856.6	7.0	Ya,	2856.7	7.5	Bs,
	2856.7	7.7	Pt,	2857.8	7.8	Pt,	2858.7	6.7	Pt,	2858.8	7.5	M.
154536 X CORONAE BOREALIS—												
	2817.8	<12.2	M,	2828.8	<13.3	Wf,	2836.6	12.6	B.	2838.8	13.5	Wf,
	2848.8	13.5	Wf,	2855.6	<12.0	Pw.						
154639 V CORONAE BOREALIS—												
	2807.7	10.4	Pt,	2817.8	9.8	M,	2835.8	9.4	Wf,	2841.6	11.0	Pt,
	2843.8	10.6	M,	2844.8	10.0	Wf,	2852.7	10.2	Wf,	2855.6	<10.0	Pw.
154615 R SERPENTIS—												
	2753.3	7.3	Ch,	2786.5	8.1	Ja,	2804.5	8.4	O.	2805.4	8.7	Pe,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
154615 R SERPENTIS—												
	2807.7	9.0	Pt,	2808.3	8.9	Pe,	2812.7	8.6	Mu,	2815.3	9.1	Pe,
	2817.8	9.0	M,	2818.5	8.8	O,	2820.6	8.9	Po,	2821.7	8.7	Mu,
	2837.7	9.7	Pt,	2839.3	10.1	Pe,	2840.6	9.4	Ca,	2840.6	9.5	O,
	2841.6	9.3	Ba,	2841.6	10.1	Po,	2845.6	9.5	O,	2850.6	10.0	Gd,
	2850.8	10.3	M.									
154715 R LIBRAE—												
	2817.8	11.4	M,	2840.6	12.5	Ba,	2843.6	12.1	Y,	2849.6	<10.6	Po,
	2849.7	13.0	B.									
155018 RR LIBRAE—												
	2753.3	11.0	Ch,	2784.6	12.4	L,	2788.2	<11.0	Ch,	2816.5	<14.5	L,
	2836.4	<13.5	L,	2840.6	<14.5	Ba,	2840.6	14.2	B,	2845.7	13.8	Pt.
155847 X HERCULIS—												
	2783.4	7.1	Pe,	2807.4	6.8	Pe,	2834.7	6.2	Mu,	2841.7	6.4	Mu,
	2843.7	6.3	Mu,	2846.7	6.2	Mu,	2847.7	6.2	Mu,	2849.7	6.3	Mu,
	2850.7	6.4	Mu.									
155823 RZ SCORPII—												
	2818.8	9.8	M,	2845.7	8.9	Pt,	2853.6	8.7	M.			
160021 Z SCORPII—												
	2792.6	11.3	L,	2816.5	11.7	L,	2839.4	12.2	L.			
160118 R HERCULIS—												
	2806.5	11.2	Ja,	2810.5	10.8	Ja,	2821.7	9.3	Mu,	2834.7	8.7	Mu,
	2840.6	8.9	Cl,	2841.6	8.4	Ba,	2844.8	8.8	M,	2845.6	<9.5	Cg,
	2856.6	8.9	O,	2856.7	8.6	Ya.						
160210 U SERPENTIS—												
	2805.6	8.3	Y,	2807.7	8.3	Pt,	2812.7	8.9	Mu,	2817.8	8.1	M,
	2821.7	8.9	Bs,	2834.7	9.0	Mu,	2836.7	8.6	Y,	2837.6	8.7	Cg,
	2837.7	8.8	Pt,	2840.6	9.2	Cl,	2840.6	9.0	O,	2841.6	9.1	Ba,
	2843.8	9.0	M,	2845.6	9.0	O,	2846.7	8.4	Bs,	2856.6	9.8	Ya.
160625 RU HERCULIS—												
	2838.9	<12.3	Wf,	2841.6	13.5	Ba,	2843.6	13.3	Y,	2848.8	<12.3	Wf,
	2849.6	<11.7	Po.									
161138 W CORONAE BOREALIS—												
	2810.7	11.1	Pt,	2820.6	11.2	Y,	2835.8	11.9	Wf,	2837.6	12.2	Y,
	2838.8	12.5	Wf,	2848.8	12.4	Wf,	2849.6	<11.5	Po,	2850.8	<11.5	M,
	2855.6	<12.0	Pw.									
161122a R SCORPII—												
	2782.5	11.3	Ja,	2786.5	11.5	Ja,	2807.5	12.3	Ja,	2810.5	12.5	Ja,
	2811.7	12.8	Pt,	2817.8	13.0	M,	2841.6	<13.0	Ba.			
161122b S SCORPII—												
	2782.5	10.7	Ja,	2786.5	10.5	Ja,	2807.5	10.7	Ja,	2810.5	10.9	Ja,
	2811.7	11.2	Pt,	2817.8	11.0	M,	2841.6	12.8	Ba.			
161122c T SCORPII—												
	2811.7	10.9	Pt,	2817.8	10.4	M,	2841.6	10.4	Ba.			
161607 W OPHIUCHI—												
	2791.5	10.4	L,	2810.7	10.5	Pt,	2816.5	9.1	L,	2838.4	10.6	L,
	2841.6	11.1	Pt,	2841.7	11.0	Ba,	2844.8	10.8	M,	2856.6	<11.0	Ya.
162112 V OPHIUCHI—												
	2811.7	9.0	Pt,	2841.7	9.0	Ba,	2853.7	9.8	M,	2855.6	10.0	B,
162119 U HERCULIS—												
	2753.4	9.3	Ch,	2782.1	9.6	Pe,	2782.6	9.5	Gi,	2788.2	10.0	Ch,
	2793.4	9.8	Pe,	2805.4	10.0	Pe,	2806.9	9.1	Ml,	2807.5	10.1	Gi,
	2810.4	10.6	Pe,	2810.7	10.8	Pt,	2815.3	10.6	Pe,	2817.8	10.8	M,
	2819.5	10.4	O,	2820.7	10.6	Bs,	2821.4	10.3	Gi,	2821.7	10.8	Mu,
	2834.8	11.2	Bs,	2839.3	11.2	Pe,	2840.6	11.4	O,	2840.7	<10.9	Ca,
	2841.6	11.1	Pt,	2841.7	10.9	Ba,	2844.8	11.4	M.			
162319 Y SCORPII—												
	2818.5	<13.0	L,	2840.4	<13.0	L.						
162542 G HERCULIS—												
	2783.4	5.2	Pe,	2807.4	5.6	Pe,	2834.7	5.1	Mu,	2841.7	5.2	Mu,
	2843.7	5.3	Mu,	2846.7	5.2	Mu,	2847.7	5.0	Mu,	2849.7	5.1	Mu,
	2850.7	5.4	Mu.									

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
162807 SS HERCULIS—												
	2781.5	9.6	L,	2801.4	9.8	L,	2816.6	11.5	L,	2841.7	12.8	Ba,
	2845.7	12.7	Pt,	2853.6	12.0	M.						
162815 T OPHIUCHI—												
	2818.5	11.0	L.									
162816 S OPHIUCHI—												
	2818.5	<11.0	L,	2840.5	11.4	L.						
163172 R URSAE MINORIS—												
	2803.8	9.4	M,	2819.5	9.6	O,	2841.6	10.3	O,	2841.7	10.0	Ba,
	2843.8	10.4	M,	2849.6	10.3	O.						
163137 W HERCULIS—												
	2753.3	<11.0	Ch,	2788.2	<11.0	Ch,	2808.6	13.0	Y,	2809.5	13.4	Ja,
	2815.6	13.1	Pt,	2820.6	12.4	Y,	2841.7	11.5	Ba,	2841.7	10.9	Pt,
	2843.8	10.9	M.									
163266 R DRACONIS—												
	2753.3	11.0	Ch,	2787.2	<11.0	Ch,	2803.8	12.4	M,	2805.6	11.8	Y,
	2810.7	12.3	Pt,	2837.6	11.1	Y,	2841.6	11.1	Pt,	2841.7	10.9	Ba,
	2843.8	10.9	M,	2849.7	10.7	Po,	2854.7	10.6	Bs.			
164055 S DRACONIS—												
	2808.8	9.0	M,	2838.6	8.2	M.						
164319 RR OPHIUCHI—												
	2818.5	12.7	L,	2840.5	<12.0	L,	2843.6	13.0	Y.			
164715 S HERCULIS—												
	2780.6	7.9	Gi,	2802.4	8.2	Gi,	2810.7	8.5	Pt,	2815.5	8.8	Gi,
	2840.5	9.6	Gi,	2840.6	9.6	Cl,	2840.6	10.0	Hs,	2840.6	9.6	Wm,
	2840.7	9.5	Ca,	2842.6	9.7	Hs,	2842.6	9.6	O,	2842.6	9.8	Wm,
	2845.6	<9.4	Cg,	2845.7	10.0	Pt,	2846.6	9.8	O,	2850.6	10.5	Hs,
	2850.8	10.2	M,	2855.6	10.2	Wm.						
165202 SS OPHIUCHI—												
	2843.6	12.8	Y.									
165631 RV HERCULIS—												
	2783.4	12.4	Pe,	2784.4	12.0	Pe,	2785.5	11.1	Ja,	2806.4	12.6	Pe,
	2806.5	12.0	Ja,	2810.5	12.5	Ja,	2810.7	12.5	Pt,	2819.5	<11.2	O,
	2821.7	<11.2	Mu,	2834.7	<11.2	Mu,	2839.7	13.6	Ba,	2839.7	13.5	M,
	2840.6	13.7	Ba,	2840.6	<12.0	Cl.						
165636 RT SCORPII—												
	2821.5	9.5	L.									
170215 R OPHIUCHI—												
	2753.4	7.0	Ch,	2772.5	7.5	Ch,	2781.3	7.3	Ch,	2810.7	8.5	Pt,
	2816.8	8.4	M,	2834.7	9.2	Mu,	2840.6	9.6	Lc,	2840.7	9.3	Ca,
	2841.7	9.8	Pt,	2843.7	9.6	Po,	2847.8	8.8	Bs,	2853.6	9.7	Gd,
	2853.6	10.0	M.									
170627 RT HERCULIS—												
	2810.7	11.4	Pt,	2834.8	12.5	Wf,	2841.7	12.7	Pt,	2843.8	12.5	Wf,
	2850.8	12.6	Wf,	2851.8	11.5	M.						
171401 Z OPHIUCHI—												
	2780.6	8.5	Gi,	2791.6	8.5	Gi,	2810.7	9.2	Pt,	2815.6	9.3	Gi,
	2840.6	10.5	Cl,	2840.7	10.6	Ca,	2841.5	9.9	Gi,	2841.7	10.1	Pt.
171723 RS HERCULIS—												
	2807.5	10.4	Ja,	2810.7	10.5	Pt,	2816.3	10.7	Pe,	2821.7	11.3	Mu,
	2834.7	<11.0	Mu,	2834.8	12.2	Wf,	2841.7	12.5	Pt,	2843.8	12.3	Wf,
	2850.8	12.4	Wf,	2853.6	12.5	M.						
172809 RU OPHIUCHI—												
	2810.7	9.6	Pt,	2817.8	9.7	M,	2841.7	9.3	Pt,	2843.8	9.5	M.
173457 TY DRACONIS—												
	2783.4	8.9	Pe.									
174406 RS OPHIUCHI—												
	2823.7	11.0	Pt,	2845.7	11.3	Pt.						
175111 RT OPHIUCHI—												
	2842.6	<11.0	Cl,	2843.6	<12.7	Y,	2845.6	<11.0	O.			
175458a T DRACONIS—												
	2784.6	11.2	Gi,	2817.4	10.1	Gi,	2841.5	10.1	Gi,	2843.6	10.6	Y.

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
175458b UY DRACONIS—												
	2843.6	11.2	Y.									
175519 RY HERCULIS—												
	2753.4	<11.7	Ch,	2806.4	12.3	Pe,	2807.2	<11.0	Ch,	2810.7	11.7	Pt,
	2817.4	11.8	Pe,	2841.7	9.1	Pt,	2854.8	8.4	M.			
180531 T HERCULIS—												
	2753.4	11.2	Ch,	2781.4	13.0	L,	2783.4	9.6	Pe,	2785.4	12.2	Pe,
	2799.4	<11.0	Ch,	2807.4	12.4	L,	2810.4	12.2	Pe,	2810.7	12.6	Pt,
	2813.4	12.0	Pe,	2817.4	11.6	L,	2817.4	11.2	Pe,	2821.7	11.2	Mu,
	2823.7	11.6	Bs,	2834.7	10.2	Bs,	2834.7	9.6	Mu,	2836.7	10.0	Ca,
	2839.4	9.6	Pe,	2840.4	9.5	L,	2840.6	9.5	O,	2841.6	9.5	Po,
	2841.7	9.4	Pt,	2843.6	9.5	Cg,	2843.8	9.0	M,	2846.6	9.2	Su,
	2850.6	9.3	O,	2853.6	9.2	Cg.						
180666 X DRACONIS—												
	2810.7	11.5	Pt,	2845.7	11.8	Pt,	2853.8	<11.8	M.			
180911 NOVA OPHIUCHI #4—												
	2781.6	11.6	L,	2791.6	11.4	Gi,	2807.7	11.4	Pt,	2814.7	11.4	Pt,
	2816.5	11.5	L,	2818.7	11.5	Pt,	2821.5	11.4	Gi,	2837.7	11.4	Pt,
	2840.4	11.4	L,	2845.7	11.4	Pt,	2850.8	11.5	Pt.			
181031 TV HERCULIS—												
	2781.5	11.5	L,	2785.4	12.2	Pe,	2807.4	14.0	L,	2810.4	<11.2	Pe,
	2819.4	13.5	L,	2836.4	<13.0	L.						
181136 W LYRAE—												
	2782.5	12.2	Ja,	2784.6	12.3	L,	2789.4	11.0	Pe,	2801.8	10.8	M,
	2809.5	10.0	Ja,	2810.7	9.7	Pt,	2816.4	9.4	L,	2817.4	9.2	Pe,
	2820.6	9.4	Y,	2821.7	9.2	Pe,	2834.7	9.2	Mu,	2835.4	8.7	L,
	2839.8	9.1	Pt,	2840.4	8.7	Pe,	2840.6	8.0	O,	2840.7	8.4	Ba,
	2842.7	8.2	Ca,	2846.6	8.0	O,	2854.8	8.1	M.			
181103 RY OPHIUCHI—												
	2801.8	8.9	M,	2806.8	8.9	Ml,	2810.7	9.0	Pt,	2834.7	12.2	Wf,
	2841.7	12.1	Pt,	2843.8	12.4	Wf,	2850.8	<13.0	Wf.			
182224 SV HERCULIS—												
	2781.5	12.1	L,	2807.4	13.4	L,	2819.4	13.6	L,	2840.4	14.0	L.
182306 T SERPENTIS—												
	2801.8	9.2	Pw,	2810.7	11.6	Pt,	2816.8	11.4	M,	2839.8	12.6	Pt,
	2854.8	12.5	M.									
183149 SV DRACONIS—												
	2808.6	13.0	Y,	2837.6	<13.0	Y.						
183225 RZ HERCULIS—												
	2808.6	10.9	Y,	2810.7	11.4	Pt,	2836.7	12.0	Y.			
183308 X OPHIUCHI—												
	2791.5	7.2	L,	2810.7	6.3	Pt,	2816.5	6.6	L,	2839.8	6.5	Pt,
	2840.4	6.9	L.	2840.7	7.2	Ba,	2843.7	6.9	Po,	2854.8	7.3	M.
184134 RY LYRAE—												
	2856.6	10.6	O.									
184243 RW LYRAE—												
	2840.7	12.3	Ba,	2845.6	11.4	O.						
184205 R SCUTI—												
	2763.4	5.6	Ch,	2784.7	5.9	L,	2790.6	6.5	L,	2792.6	6.9	L,
	2795.4	6.3	Ch,	2807.7	7.3	Cd,	2807.7	8.0	Pt,	2810.7	7.7	Pt,
	2813.8	7.1	Cd,	2814.8	6.6	Pt,	2815.8	6.3	Pt,	2816.5	6.9	L,
	2817.8	7.5	M,	2819.6	6.7	Cd,	2820.6	6.5	L,	2821.5	6.6	Gi,
	2823.7	6.1	Pt,	2825.7	5.6	Pt,	2826.8	5.8	M,	2826.8	6.0	Pt,
	2834.6	5.5	Cd,	2837.7	5.8	Pt,	2839.8	5.8	Pt,	2840.5	5.2	L,
	2840.6	5.6	Ba,	2840.7	5.7	Ca,	2841.7	5.6	Pt,	2842.7	5.7	Ca,
	2843.7	5.2	Mu,	2843.8	5.2	M,	2845.6	5.6	Cd,	2845.7	5.6	Pt,
	2846.7	5.0	Mu,	2847.7	4.9	Mu,	2849.7	5.0	Mu,	2850.7	4.8	Mu,
	2850.8	5.4	Pt,	2852.8	5.3	Pt,	2853.8	5.6	Ca,	2854.8	5.2	Pt,
	2855.6	5.4	Wl,	2855.7	5.1	Po,	2855.7	5.5	Ca,	2856.7	5.2	Pt.
184300 NOVA AQUILAE #3—												
	2763.4	8.8	Ch,	2782.6	9.6	Gi,	2792.6	9.5	L,	2795.4	9.0	Ch,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
184300 Nova Aquilae #3—								
	2807.7	9.4 Pt,	2810.7	9.3 Pt,	2814.8	9.5 Pt,	2816.6	9.1 L,
	2817.8	9.1 M,	2821.5	9.7 Gi,	2823.7	9.5 Pt	2826.8	9.2 M
	2837.7	9.1 Pt,	2840.4	9.5 L,	2840.7	9.1 Ba,	2842.7	9.4 Ca,
	2843.8	9.2 M,	2845.7	9.6 Pt,	2850.8	9.6 Pt.		
184929 U Lyrae—								
	2821.5	13.1 Gi.						
185032 RX Lyrae—								
	2782.5<13.0 Ja,		2809.5<13.0 Ja.					
185634 Z Lyrae—								
	2815.5<13.8 L,		2840.4<13.8 L,		2850.6<10.9 O.			
185512a ST Sagittarii—								
	2820.6<12.0 L,		2821.5<12.5 L.					
185737 RT Lyrae—								
	2843.6<13.3 Y.							
190108 R Aquilae—								
	2810.7	11.2 Pt,	2845.7	10.8 Pt,	2855.7	9.8 Po.		
190529a V Lyrae—								
	2782.5	11.0 Ja,	2809.5	10.2 Ja,	2810.7	9.7 Pt,	2820.6	10.7 Y,
	2841.7	10.6 Pt,	2843.6	10.7 Y,	2854.8	11.5 M.		
190941 RU Lyrae—								
	2843.6<13.3 Y.							
190925 S Lyrae—								
	2781.6	12.6 L,	2816.4	13.2 L,	2816.6	13.0 M,	2836.4	13.3 L.
190926 X Lyrae—								
	2810.7	9.0 Pt,	2818.8	9.1 M,	2841.7	9.0 Pt,	2850.6	9.2 O,
	2853.6	9.1 M.						
190933a RS Lyrae—								
	2810.7	11.9 Pt.						
190967 U Draconis—								
	2810.7	11.0 Pt,	2816.8	11.8 M,	2841.7	12.5 Pt.		
191019 R Sagittarii—								
	2814.8	12.1 Pt,	2842.7	11.0 Ca,	2845.7	12.0 Pt.		
191033 RY Sagittarii—								
	2784.7	5.9 L,	2790.6	6.7 L,	2814.8	6.1 Pt,	2815.8	6.0 Pt,
	2816.6	6.0 L,	2820.6	6.7 L,	2823.7	6.5 Pt,	2826.8	6.4 Pt,
	2839.8	8.0 Pt,	2840.5	7.6 L,	2841.7	7.8 Pt,	2845.7	7.8 Pt,
	2846.8	7.8 Pt,	2852.8	7.9 Pt,	2857.8	7.9 Pt.		
191350 TZ Cygni—								
	2810.7	11.8 Pt,	2820.6	10.1 Y,	2834.6	10.4 Y,	2840.7	10.5 Ba,
	2841.7	10.5 Pt,	2842.6	10.4 Y.				
191319 S Sagittarii—								
	2842.7<11.1 Ca.							
191637 U Lyrae—								
	2786.5	11.0 Ja,	2801.8	10.3 M,	2809.5	11.0 Ja.	2810.7	10.9 Pt,
	2839.8	11.9 Pt,	2853.7	10.6 M,	2855.7	11.1 Po.		
192928 TY Cygni—								
	2840.7	13.0 Ba,	2844.8<12.4 M,		2849.6<10.4 O.			
193449 R Cygni—								
	2763.5	7.0 Ch,	2772.4	7.6 Ch,	2786.4	7.8 Ch,	2789.4	6.3 Pe,
	2795.4	8.5 Ch,	2806.4	9.1 Pe,	2807.4	8.9 Pe,	2810.7	8.1 Pt,
	2810.8	8.0 M,	2816.4	9.0 Pe,	2821.7	9.0 Mu,	2834.7	9.1 Mu,
	2839.3	9.7 Pe,	2839.8	8.9 Pt,	2840.3	9.8 Pe,	2840.7	9.2 Ba,
	2841.6	9.9 Pe,	2842.6	9.0 O,	2843.8	9.3 M,	2849.6	9.6 O.
193509 RV Aquilae—								
	2810.7	12.8 Pt.						
193732 TT Cygni—								
	2843.8	7.8 M,	2845.6	7.6 Cl.				
194048 RT Cygni—								
	2763.5	9.5 Ch,	2782.6	9.9 Gi,	2795.4<11.0 Ch,		2810.8	11.5 M,
	2810.8	12.3 Pt,	2814.6	11.5 Gi,	2821.7	9.1 Mu,	2834.7	9.5 Mu,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
194048 RT CYGNI—												
	2839.5	9.8	Gi,	2839.8	9.7	Pt,	2840.4	10.8	Pe,	2840.7	10.0	Ba,
	2841.4	10.4	Pe,	2843.8	9.1	M.						
194348 TU CYGNI—												
	2810.8	9.0	M,	2810.8	9.5	Pt,	2839.8	10.2	Pt,	2840.7	10.2	Ba,
	2843.8	11.0	M.									
194604 X AQUILAE—												
	2810.8	11.6	Pt,	2810.8	11.2	M,	2838.8	12.3	Wf,	2843.8	<12.3	M,
	2848.8	12.5	Wf.									
194632 χ CYGNI—												
	2782.6	<12.5	Ja,	2798.2	<11.0	Ch,	2807.4	<12.2	Pe,	2810.4	11.9	Pe,
	2823.7	11.4	Pt,	2838.4	10.2	Rk,	2840.6	11.8	Cl,	2841.7	11.1	Pt,
	2843.7	10.5	Lc,	2843.8	10.6	M.						
195116 S SAGITTAE—												
	2834.7	5.4	Mu,	2841.7	5.8	Mu,	2843.7	6.2	Mu,	2846.7	5.7	Mu,
	2847.7	5.5	Mu,	2849.7	5.4	Mu,	2850.7	5.7	Mu.			
195553 NOVA CYGNI #3—												
	2782.6	9.8	Gi,	2787.6	9.9	Mt	2792.6	8.8	L,	2803.7	9.6	Pt,
	2807.7	9.2	Pt,	2808.4	10.2	Mt,	2808.7	9.4	Pt,	2810.7	9.3	Pt,
	2814.8	9.5	Pt,	2816.6	9.2	L,	2816.7	9.4	Pt,	2819.6	9.9	Gi,
	2820.6	9.4	Y,	2823.7	9.5	Pt,	2825.7	9.5	Pt,	2835.4	9.2	L,
	2837.7	9.3	Pt,	2839.8	9.4	Pt,	2841.7	9.5	Pt,	2845.7	9.5	Pt,
	2850.8	9.5	Pt,	2850.9	9.3	Ka,	2852.8	9.3	Pt,	2858.7	9.4	Pt.
195849 Z CYGNI—												
	2783.6	12.5	Gi,	2810.8	12.0	M,	2810.8	12.6	Pt,	2816.4	<11.6	Pe,
	2821.5	<12.7	Gi,	2838.8	12.7	Wf,	2839.6	<13.8	Gi,	2841.7	12.8	Pt,
	2843.8	12.4	M,	2848.8	12.8	Wf,	2849.7	12.5	Wf,	2850.7	12.5	Wf.
200212 SY AQUILAE—												
	2792.6	9.6	L,	2816.6	10.5	L,	2838.4	11.1	L.			
200357 S CYGNI—												
	2814.8	10.9	Pt,	2818.8	10.5	M,	2841.7	11.2	Pt,	2843.8	11.7	M.
200647 SV CYGNI—												
	2821.7	8.8	Mu,	2843.7	8.8	Mu.						
200747 RX CYGNI—												
	2821.7	7.8	Mu,	2843.7	7.8	Mu.						
200715a S AQUILAE—												
	2780.7	9.9	Gi,	2792.7	11.2	Gi,	2814.8	10.9	Pt,	2815.6	10.2	Gi,
	2816.8	10.3	M,	2839.6	9.9	Gi,	2841.7	10.1	Pt,	2843.8	10.0	M.
200715b RW AQUILAE—												
	2816.8	8.8	M,	2843.8	8.9	M.						
200822 W CAPRICORNI—												
	2850.8	12.0	Pt.									
200906 Z AQUILAE—												
	2814.8	11.6	Pt,	2821.6	12.5	Gi.						
200938 RS CYGNI—												
	2763.5	8.2	Ch,	2772.4	8.0	Ch,	2784.7	7.6	L,	2797.4	8.5	Ch,
	2803.8	8.8	M,	2814.8	8.5	Pt,	2816.5	7.8	L,	2835.4	7.9	L,
	2841.4	8.8	Pe,	2841.7	8.3	Pt,	2843.8	8.7	M.			
200916 R SAGITTAE—												
	2816.8	8.4	M,	2843.8	9.5	M.						
201008 R DELPHINI—												
	2818.5	<12.8	L.									
201130 SX CYGNI—												
	2818.8	<12.0	M,	2836.6	<13.3	Y,	2850.8	<12.0	M.			
201131 RT CAPRICORNI—												
	2784.7	6.4	L,	2820.6	6.7	L,	2840.5	6.8	L.			
201139 RT SAGITTARII—												
	2815.8	6.5	Pt.									
201437a P CYGNI—												
	2763.5	4.7	Ch,	2772.5	4.6	Ch,	2797.4	4.8	Ch,	2840.3	5.2	Pe,
	2841.4	5.0	Pe.									

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
201647 U CYGNI—								
	2784.6	8.2 Gi,	2803.8	7.7 M,	2810.4	9.8 Pe,	2814.8	8.0 Pt,
	2816.4	9.4 Pe,	2816.6	8.9 Gi,	2821.7	7.6 Mu,	2841.7	8.8 Pt,
	2843.7	8.0 Mu,	2843.8	10.0 M,	2855.6	10.0 Wl,	2856.6	9.9 Po.
202539 RW CYGNI—								
	2803.8	9.0 M,	2843.8	8.6 M.				
202817 Z DELPHINI—								
	2814.8	10.2 Pt,	2841.7	9.5 Pt,	2850.8	9.5 M.		
202954 ST CYGNI—								
	2803.8	10.6 M,	2814.8	11.1 Pt,	2820.6	11.0 Y.	2834.6	10.6 Y,
	2844.8	11.3 M,	2845.7	11.4 Pt.				
202946 SZ CYGNI—								
	2803.8	9.3 M,	2843.8	10.2 M.				
203226 V VULPECULAE—								
	2803.8	8.9 M.	2814.8	8.8 Pt,	2845.7	9.1 Pt.		
203847 V CYGNI—								
	2783.6	10.2 Gi,	2799.4<10.9 Ch,		2815.6	9.5 Gi,	2816.8	11.4 M,
	2844.8	9.9 M.						
203816 S DELPHINI—								
	2816.8	9.3 M,	2843.8	9.8 M.	2856.6	8.9 Po.		
204016 T DELPHINI—								
	2814.8	12.9 Pt,	2816.8<12.6 M,		2823.9<12.8 Wf,		2838.8<14.0 Wf.	
	2843.8<12.2 M,		2848.8<14.0 Wf.					
204104 W AQUARII—								
	2816.6	10.9 L,	2840.5	11.0 L.				
204318 V DELPHINI—								
	2790.6<13.6 Gi,		2821.6<13.6 Gi,		2840.5<13.6 Gi.			
204405 T AQUARII—								
	2772.5	7.6 Ch,	2798.4	8.2 Ch,	2814.8	9.7 Pt,	2842.8	11.5 Ca,
	2850.8	12.1 Pt.						
204846 RZ CYGNI—								
	2790.6	14.1 Gi,	2819.6	14.1 Gi,	2840.6	14.1 Gi,	2845.6<11.1 O.	
205030a UX CYGNI—								
	2818.8	11.5 M.						
205923 R VULPECULAE—								
	2783.7	8.5 Gi,	2802.6	9.7 Gi,	2803.8	10.1 M,	2814.8	11.6 Pt,
	2816.6	11.6 Gi,	2854.8	11.2 M.				
210129 TW CYGNI—								
	2803.8	10.6 M,	2814.8	12.5 Pt,	2836.6	12.7 Y.		
210382 X CEPHEI—								
	2834.6<13.0 Y.							
210504 RS AQUARII—								
	2816.6	10.9 L,	2840.5	11.0 L.				
210868 T CEPHEI—								
	2766.4	7.2 Ch,	2783.4	6.2 L,	2786.4	5.8 Ch,	2794.4	6.6 L,
	2808.7	6.5 Cg,	2814.4	6.1 L,	2814.8	6.2 Pt,	2819.8	7.1 Cg,
	2835.4	6.4 L,	2836.6	7.1 Cg,	2845.6	7.4 O,	2845.7	6.9 Pt,
	2851.8	7.7 M,	2853.6	7.5 Cg.				
213244 W CYGNI—								
	2784.6	5.6 L,	2786.5	6.5 Pe,	2790.6	5.8 L,	2816.5	6.1 L,
	2835.4	6.2 L,	2839.4	6.3 L,	2840.3	6.6 Pe.		
213678 S CEPHEI—								
	2783.4	8.4 Gi,	2803.8	9.2 M,	2815.4	8.4 Gi,	2823.7	8.5 Pt,
	2844.8	9.2 M.	2845.7	8.0 Pt.				
213753 RU CYGNI—								
	2803.8	8.8 M,	2843.8	8.5 M.				
213843 SS CYGNI—								
	2763.5<11.0 Ch,		2782.6	11.7 Ja,	2782.7	11.8 Gi,	2783.7	11.8 Gi.
	2784.6	11.7 Gi,	2784.6	11.7 L,	2785.5	11.6 Ja,	2786.4<11.0 Ch,	
	2786.5	11.7 Ja,	2787.6	11.8 Mt,	2790.6	11.7 Gi,	2790.6	11.5 L,
	2791.7	11.7 Gi,	2792.6	11.9 L,	2801.5	10.7 L,	2803.8	9.3 M,

VARIABLE STAR OBSERVATIONS, April 20 to June 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213843 SS CYGNI—												
	2804.8	8.4	M,	2805.7	8.5	Du,	2807.4	8.1	L,	2807.5	8.3	Ja,
	2807.7	8.2	Pt,	2808.7	8.2	Pt,	2809.5	8.3	Ja,	2810.5	8.3	Ja,
	2810.7	8.3	Pt,	2810.8	8.3	M,	2810.8	8.3	Po,	2811.7	8.4	Pt,
	2814.5	8.8	Gi,	2814.8	8.6	Pt,	2815.6	9.0	Gi,	2815.8	9.0	Pt,
	2816.5	9.6	L,	2816.6	9.5	Gi,	2816.7	9.1	Pt,	2816.8	9.3	M,
	2817.4	9.7	L,	2817.8	9.8	M,	2818.4	10.2	L,	2818.6	10.3	Gi,
	2818.7	10.3	Pt,	2818.8	10.5	M,	2819.4	10.3	L,	2819.6	10.9	Gi,
	2819.7	10.5	Du,	2820.6	11.2	Gi,	2820.6	10.4	L,	2820.6	11.0	Y,
	2821.6	11.5	Gi,	2821.6	10.8	L,	2821.7	11.3	Du,	2823.7	11.9	Pt,
	2823.8	11.9	Wf,	2825.7	11.9	Pt,	2826.8	11.8	Pt,	2835.4	11.7	L,
	2835.8	12.0	Wf,	2836.4	11.6	L,	2836.6	12.0	Y,	2837.7	11.9	Pt,
	2838.4	11.7	L,	2838.9	12.2	Wf,	2839.4	11.7	L,	2839.4	12.0	Pe,
	2839.5	11.8	Gi,	2839.8	11.9	Pt,	2840.4	11.9	Pe,	2840.5	11.8	Gi,
	2840.5	11.5	L,	2840.6	<11.3	Cl,	2840.7	11.8	Ba,	2840.7	11.9	Pt,
	2840.7	11.8	Po,	2840.8	11.9	Wf,	2841.5	11.8	Gi,	2841.7	11.9	Pt,
	2841.7	11.7	Ba,	2842.6	11.9	Y,	2842.7	11.8	Po,	2843.7	11.9	Wf,
	2843.8	11.7	M,	2844.8	12.0	M,	2844.8	12.0	Wf,	2845.6	<11.8	Cl,
	2845.6	<10.9	O,	2845.7	11.9	Pt,	2846.6	<10.9	O,	2846.8	11.9	Pt,
	2848.6	<11.3	Cl,	2848.8	11.8	Wf,	2849.6	<10.9	O,	2849.8	11.8	Wf,
	2850.6	<10.5	O,	2850.7	11.8	Wf,	2850.8	12.0	M,	2850.8	11.8	Pt,
	2852.7	11.9	Wf,	2852.8	11.9	Pt,	2853.7	11.8	Wl,	2854.8	11.9	Pt,
	2855.6	<11.3	Cl,	2855.6	<10.5	O,	2855.7	11.8	Po,	2856.6	<10.5	O,
	2856.7	11.9	Pt,	2856.7	11.8	Po,	2857.8	11.6	Pt.	2858.7	11.8	Pt.
213937 RV CYGNI—												
	2816.8	8.0	M,	2844.8	7.9	M.						
214024 RR PEGASI—												
	2814.8	11.0	Pt,	2850.8	9.1	Pt.						
220412 T PEGASI—												
	2816.6	10.1	L,	2840.5	9.4	L.						
222439 S LACERTAE—												
	2792.6	11.1	L,	2816.5	13.1	L,	2819.6	12.9	Gi,	2840.5	13.7	L.
223841 R LACERTAE—												
	2816.5	<14.0	L,	2821.6	<13.6	Gi,	2840.5	13.5	L.			
230110 R PEGASI—												
	2806.9	8.9	Ml,	2815.8	9.6	Pt.						
230759 V CASSIOPEIAE—												
	2783.3	11	5.Gi,	2814.8	10.7	Pt,	2820.6	10.1	Gi,	2840.6	9.0	Gi,
	2850.8	8.0	Pt,	2855.7	8.0	Wl.						
231425 W PEGASI—												
	2792.6	9.4	L,	2820.6	10.2	L,	2840.5	11.6	L.			
231508 S PEGASI—												
	2850.8	11.1	Pt.									
233335 ST ANDROMEDAE—												
	2799.4	9.3	Ch,	2840.8	9.8	Wf,	2849.8	10.0	Wf,	2850.8	10.7	Pt.
233956 Z CASSIOPEIAE—												
	2823.8	<13.4	Wf,	2840.8	<13.4	Wf,	2848.9	<13.3	Wf.			
235053 RR CASSIOPEIAE—												
	2780.3	11.1	Gi,	2820.6	11.0	Gi,	2840.6	11.4	Gi.			
235525 Z PEGASI—												
	2826.8	8.1	Pt,	2850.8	8.0	Pt.						
235855 Y CASSIOPEIAE—												
	2780.3	12.1	Gi.									

Total Observations: 2,456. Stars Observed: 283. Observers: 43.

Godfrey "Gd," Hall "Hl," Misses Hall "Hm" and Hawes "Hs," Janczewski "Ja," Kaster "Ka," Miss Jenkins "Jk," Lacchini "L," Lacy "Lc," Leavenworth "Lv," McAteer "M," Merrill "Ml," Merton "Mt," Mundt "Mu," Murray "My," Nakamura "Nk," Olcott "O," Mrs. Olcott "Mo." Peltier "Pt," de Perrot "Pe,"

Pickering "Pi," Potter "Po," Reesinck "Rk," Rhorer "Ro," Suter "Su," Waldo "Wl," Waterfield "Wf," Watson "Pw," Williams "Wm," Yalden "Ya," Yamamoto "Ym," and Miss Young "Y."

ARVILLE D. WALKER, Recording Secretary.

COMET NOTES.

Winnecke's Comet.—Professor R. T. Crawford has communicated the following elements of Winnecke's Comet, based upon observations on April 12, 29, and June 7. Perturbations due to the action of the Earth have been taken into account, and no assumption has been made regarding period.

ELEMENTS

Time of perihelion passage	(T)	1921, June 12.93046 G. M. T.
Perihelion minus node	(ω)	170° 19′ 56″
Longitude of node	(Ω)	98° 1′ 51″
Inclination	(i)	18° 49′ 43″
Perihelion distance	(q)	1.0406
Semi-major axis	(a)	3.2321
Mean daily motion	(μ)	610″.628
Eccentricity	(e)	0.678047
Periodic time	(P)	5.81073 years.

CONSTANTS FOR THE EQUATOR, 1921.0

$$x = r\,[9.976607]\,\sin\,(358°\ 48'\ 38'' + v)$$
$$y = r\,[9.974105]\,\sin\,(275°\ 42'\ 15'' + v)$$
$$z = r\,[9.665755]\,\sin\,(228°\ 37'\ 18'' + v)$$

Harvard College Observatory Bulletin 755. S. I. BAILEY.
Cambridge, Mass., U. S. A., June 25, 1921.

Elements of Pons-Winnecke's Comet.—The following elements were computed from the positions of the comet on April 12, May 7, and May 31, all by Professor Barnard at the Yerkes Observatory:

T	= May 31.7535 G. M. T. 1921
M	= 357° 59′ 48″.71
ω	= 170° 17′ 18″.07
π	= 268° 23′ 46″.87
Ω	= 98° 6′ 28″.80
i	= 18° 54′ 36″.84
Log e	= 9.8352121
Log a	= 0.5180224
Log q	= 0.0173717
μ	= 592″.888

CONSTANTS.

$$x = r\,[9.9764102]\,\sin\,(188°\ 33'\ 50''.03 + u)$$
$$y = r\,[9.9742350]\,\sin\,(105°\ 28'\ 10''.66 + u)$$
$$z = r\,[9.6660434]\,\sin\,(\ 58°\ 12'\ 2''.56 + u)$$

A comparison of the ephemeris based upon the above elements with an observation made at Greenwich on June 2 shows the corrections on that date to be as follows:

$$O - C,\ \Delta\alpha = +0^s.85;\ \Delta\delta = -10''.59.$$

F. E. SEAGRAVE.

COMMUNICATIONS.

Celestial Missiles, A Word About Meteors.—In discussing the subject "Celestial Missiles" we have two classes with which to deal: the meteors, which shortly after their entrance in earth's atmosphere, disappear from view; and the meteorites, which actually strike our planet's surface. Regarding the subsequent fate of the meteors there is some question. The majority of astronomers believe they are disintegrated by violent friction with the atmosphere. Others hold they pass through a section of the atmosphere and enter outer space. Both opinions have weight. In consideration of the law that a body passing at a tremendous rate through a resisting medium must disintegrate, one would conclude that such is the fate of the meteor. On the other hand the condition of the meteorite at the moment of its impact with earth's surface contradicts this conclusion. Its solidity is not impaired. It does not retain enough of the heat which it momentarily incurred to char dry twigs. No doubt both theories are true. The fate of the meteor depends on its constitution and velocity.

Astronomers have advanced many different theories for the origin of meteors —all of which possibly are true. Meteoric phenomena are so diversified that a large number of causes may reasonably be considered as operating. Some meteors and meteorites, no doubt, are fragments of comets and planets which have met disaster. Others probably were hurled from prehistoric terrestrial volcanoes. A few even may have found their origin in the tremendous lunar cataclysms. By far the greater majority of them, however, must be condensed particles of ancient nebulae which fall peaceably through space until they are seized by some comet or collide with a planet or sun. Meteors and meteorites are the debris of the Universe.

RUFUS O. SUTER, JR.

Aurora in 1886.—The description of the auroral effect observed to the southeast from Riverside Drive, New York City, on the night of May 14th ult., published in your June-July number, induces me to record the account of a peculiar phenomenon observed in Florida about the year 1886, by the late Col. A. F. Wrotnowski, who was with James B. Eads and E. L. Corthell on the Mississippi jetties work.

The strange character of the occurrence so impressed me that I am able to recall almost verbatim his words in the description given to me by him in 1910, when I met him in Mexico.

He said, "I was making some preliminary surveys for canals, and was camped in a house boat at the middle of a large lake in Southeastern Florida. We were far from any settlement.

"I awoke a little before 3:00 A. M. and noticed that it was very light, and as there was no moon, got up and went out on the deck, and to my surprise saw everything illuminated with a pale greenish light so intense that we could read by it.

"I woke up the rest of the party, some 8 or 10 men and we all watched the phenomenon with great astonishment.

"The atmosphere was hazy, and we could not make out the stars, and the

light seemed to be general and from no particular direction. I remember we got out a newspaper and the print could be easily read.

"The illumination lasted fully an hour and gradually faded away to normal.

"We discussed the occurrence for days, but never reached any plausible solution of it."

Col. Wrotnowski was a man of the highest character and of unquestionable veracity, and the similarity of the green color described, and that noted by Mr. Wilson in New York in the direction of Arcturus, leads me to believe that while the New York effect was local to that region, the above occurrence, though so far south, must have been from an aurora.

DAVID FLEMING.

"Washington Suburban Sanitary District,"
Hyattsville, Maryland.
June 14, 1921.

GENERAL NOTES.

The next issue of POPULAR ASTRONOMY, the October number, will be mailed about October 1.

Professors Henri Deslandres, Albert Einstein, and Peter Zeeman have been elected foreign Members of the Royal Society.—(*The Observatory*, June, 1921.)

Professor Herbert C. Wilson returned to Northfield from California late in June. He is spending the months of July and August at his summer cottage on Turtle Lake near Bemidji, Minnesota.

Professor Edward A. Fath left Northfield on July 5 with his family by automobile. Professor Fath motored to the Yerkes Observatory where he is spending the greater part of the summer.

Professor C. H. Gingrich is spending a part of the summer in measuring parallax plates at the Dearborn Observatory. Professor Gingrich has been granted a sabbatical furlough for one year. In September he and his wife and daughter will go to California and visit the large observatories on the Pacific coast.

Mr. F. C. Leonard of Chicago, a post graduate student and teaching fellow in the University of California, has been appointed to a University fellowship in the Lick Observatory for the academic year 1921-22.—(*Pub. Astron. Soc. of the Pacific*, June, 1921.)

Dr. Hamilton M. Jeffers, Fellow in the Lick Observatory during the year 1920, passed the examinations for the Ph. D. degree in January, 1921, and since that date he has been filling the position of instructor in mathematics and astronomy in the University of Iowa.—(*Pub. Astron. Soc. of the Pacific*, June, 1921.)

Meteor Explodes Near Blanco, Texas.—One of the largest meteors ever seen fell Tuesday night, June 9, at about nine o'clock. It made a light that was visible for several miles and a loud report like an explosion followed.

Mnemonics in Numbers.—From *L'Astronomie* for May 1921 we take the following note: the value of the fraction $1/\pi$ to seven places of decimals is 0.3183098---. To some this figure may be a difficult one to remember, and in such a case one might be led to exclaim, "Oh, how I remember you; oh difficult equation," in which if "Oh" be taken to represent 0 the words in order contain letters in number corresponding to the consecutive digits.

Four Astronomers from Chicago and Evanston spent Saturday and Sunday, July 23 and 24, at the Yerkes Observatory. Professor L. Silberstein, who is giving a course of lectures on relativity in the University of Chicago this summer, Professor Henry Gale and Professor W. D. MacMillan of the University of Chicago, and Professor Philip Fox, Director of the Dearborn Observatory, Evanston, composed the group. While there it was discovered that Professor MacMillan was celebrating a birthday, and Mrs. Frost, with her accustomed hospitality prepared a suitable cake with an appropriate number of candles. The party returned to Chicago and Evanston on Monday morning.

Note on Radio Signals.—The lags of Arlington and Annapolis have generally been measured once and sometimes twice per day since the latter part of April. The best known values of these lags, and the probable errors as indicated by the discordance of the results for individual dates are as follows:

For Arlington	$0^s.088 \pm 0^s.003$
For Annapolis	$0^s.078 \pm 0^s.006$

The value for Arlington is exceedingly close to that obtained earlier in the year with the old tuning set and a crystal detector. The first few results for this station showed great variation, but the Western Union changed the direct line to Arlington in some respect, after which a great improvement has been noted. The first results were omitted in deriving the above data. The probable error given is really composed of both the error of the recording apparatus and the variation in the lag itself.

The value for Annapolis is larger by about a hundredth of a second than previous determinations. The probable error is larger than in the case of Arlington because the lag of the recording relay is greater for Annapolis, and therefore more uncertain. This is due to the fact that Annapolis operates on a double

wave. However, certain alterations will be made which should reduce the lag of the recorder to a few thousandths of a second.

The French signals have been observed on sixteen dates since May 4. The Observatory has written asking the observed times of these signals at Paris, and if these data are received in time the results for each observation will be furnished with the next monthly report. The systematic errors of this method of observation have not yet been investigated. Owing to lack of time the automatic recording of Bordeaux has not yet been accomplished, but it is now hoped to do this by the first of August. The time of day of the Bordeaux signal is the worst possible from the standpoint of transmission, and it may be necessary to choose a more favorable hour for successful recording.

G. E. Gelm,
Captain, U. S. Navy,
Acting Superintendent.

American Astronomical Society, Twenty-sixth Meeting.—On the invitation of Professor Frederick Slocum, the twenty-sixth meeting of the American Astronomical Society will be held at the Van Vleck Observatory, Wesleyan University, Middletown, Connecticut, from Tuesday, August 30 to Thursday, September 1, 1921.

The headquarters for the meeting will be the Psi Upsilon Fraternity House, at the corner of College and High Streets. It is planned to use this and other college houses to lodge the members and their guests. Meals for all will be served in the Psi Upsilon House. The flat rate from Monday evening, including supper, to Friday morning, including breakfast, will be $13.00. For those who are in attendance only part of the time, the rates will be: room $1.00, supper Monday night 75c, breakfast 75c, luncheon $1.00, dinner $1.25. No tips. Members should write in advance to Professor Slocum for reservations, and should state whether they desire supper on Monday evening.

The following program has been arranged:

Monday, August 29, 1921

8 P. M. Meeting of the Council, Van Vleck Observatory.

Tuesday, August 30

10 A. M. Opening session for papers, Lecture room, John Bell Scott Laboratory.
2 P. M. Session for papers, Scott Laboratory.
4 P. M. Motor ride. Hike.
8 P. M. Reception at the Van Vleck Observatory.

Wednesday, August 31

9 A. M. Meeting of the Council, Van Vleck Observatory.
10 A. M. Session for papers, Scott Laboratory.
2 P. M. Session for papers, Scott Laboratory.
4 P. M. Boat trip on the Connecticut River.

Thursday, September 1

9 A. M. Meeting of the Council, Van Vleck Observatory.
10 A. M. Session for papers, Scott Laboratory.
2 P. M. Session for papers. Election of Officers. Scott Laboratory.
4:30 to 6 P. M. Tea at the home of President and Mrs. Shanklin.
8 P. M. Conversazione, exhibits, etc., Scott Laboratory.

Titles of papers which are received by the secretary at Urbana by August 10 will be placed on the printed program, subject to the approval of the Council.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed on a supplementary program to be called for if time permits. Abstracts of papers read only by title will be included as heretofore in the printed report. Members are urged to send in titles and abstracts as promptly as possible.

The Council as usual requests members to bear the following points in mind when preparing papers. When the author of a paper is not present at a meeting, his communication should be adapted to oral presentation; certain details, although indispensible for complete publication, should not be read in extenso. It is also suggested that even when presenting our own papers most of us are more interesting when we are speaking than when we are reading. The great advantage of a scientific meeting is to bring out informal discussion and exchange of views, leaving the study of difficult or technical details to the convenience of those particularly interested.

JOEL STEBBINS,
Secretary.

Urbana, Illinois.
July 1, 1921.

CYGNUS.

Cygnus, if that haze of my first faith
Had never vanished, leaving me alone
And in the glare of light, might be kneeling
Toward you, there leaning in the western sky.

I should have known you in those misty years.
And worshipped under you, no man-made cross;
For you would mean still more to me, had you
Been linked with my old passionate belief.

But now it is too late. I cannot bow
With fervor once I knew; yet you shall be
A braver cross than one of trembling faith.
For you shall uphold striving after truth.

And you shall ever guide me, you shall be
A symbol of the bold and far and free,—
A God-made symbol for a struggling creed
That may have triumphed on old worlds now dead.

Guide me, Cygnus, I may be alone
Except for you. In Summer hang above me,
And in the Autumn face me from the west,
And then in Winter I shall strive alone,—
Alone until the Spring and your return.

—LAURENCE CARTER.